Forward Markets and Contracts

Study Session 17

Exam Focus

This topic review introduces forward contracts in general and covers the characteristics of forward contracts on various financial securities, as well as interest rates. It is not easy material, and you should take the time to learn it well. This material on forward contracts provides a good basis for futures contracts and many of the characteristics of both types of contracts are the same. Take the time to understand the intuition behind the valuation of forward rate agreements.

Forward Contracts

A **forward contract** is a bilateral contract that obligates one party to buy and the other to sell a specific quantity of an asset, at a set price, on a specific date in the future. Typically, neither party to the contract pays anything to get into the contract. If the expected future price of the asset increases over the life of the contract, the right to buy at the contract price will have positive value, and the obligation to sell will have an equal negative value. If the future price of the asset falls below the contract price, the result is opposite and the right to sell (at an above-market price) will have the positive value. The parties may enter into the contract as a speculation on the future price. More often, a party seeks to enter into a forward contract to hedge a risk it already has. The forward contract is used to eliminate uncertainty about the future price of an asset it plans to buy or sell at a later date. Forward contracts on physical assets, such as agricultural products, have existed for centuries. The Level I CFA curriculum, however, focuses on their (more recent) use for financial assets, such as T-bills, bonds, equities, and foreign currencies.

LOS 61.a: Explain delivery/settlement and default risk for both long and short positions in a forward contract.

CFA® Program Curriculum, Volume 6, page 28

The party to the forward contract that agrees to buy the financial or physical asset has a **long forward position** and is called the *long*. The party to the forward contract that agrees to sell or deliver the asset has a **short forward position** and is called the *short*.

We will illustrate the mechanics of the basic forward contract through an example based on the purchase and sale of a Treasury bill. Note that while forward and futures contracts on T-bills are usually quoted in terms of a discount percentage from face value, we will use dollar prices to make the example easy to follow. Actual pricing conventions and calculations are among the contract characteristics covered later in this review.

Consider a contract under which Party A agrees to buy a $1,000 face value, 90-day Treasury bill from Party B 30 days from now at a price of $990. Party A is the long and Party B is the short. Both parties have removed uncertainty about the price they will pay/receive for the T-bill at the future date. If 30 days from now T-bills are trading at $992, the short must deliver the T-bill to the long in exchange for a $990 payment. If T-bills are trading at $988 on the future date, the long must purchase the T-bill from the short for $990, the contract price.

Each party to a forward contract is exposed to **default risk** (or **counterparty risk**), the probability that the other party (the counterparty) will not perform as promised. It is unusual for any cash to actually be exchanged at the inception of a forward contract, unlike futures contracts in which each party posts an initial deposit (margin) as a guarantee of performance.

At any point in time, including the settlement date, only one party to the forward contract will owe money, meaning that side of the contract has a negative value. The other side of the contract will have a positive value of an equal amount. Following the example, if the T-bill price is $992 at the (future) settlement date and the short does not deliver the T-bill for $990 as promised, the short has defaulted.

LOS 61.b: Describe the procedures for settling a forward contract at expiration, and how termination prior to expiration can affect credit risk.

CFA® Program Curriculum, Volume 6, page 29

The previous example was for a **deliverable forward** contract. The short contracted to deliver the actual instrument, in this case a $1,000 face value, 90-day T-bill.

This is one procedure for settling a forward contract at the *settlement date* or expiration date specified in the contract.

An alternative settlement method is **cash settlement**. Under this method, the party that has a position with negative value is obligated to pay that amount to the other party. In the previous example, if the price of the T-bill were $992 on the expiration date, the short would satisfy the contract by paying $2 to the long. Ignoring transactions costs, this method yields the same result as asset delivery. If the short had the T-bill, it could be sold in the market for $992. The short's net proceeds, however, would be $990 after subtracting the $2 payment to the long. If the T-hill price at the settlement date were $988, the long would make a $2 payment to the short. Purchasing a T-bill at the market price of $988, together with this $2 payment, would make the total cost $990, just as it would be if it were a deliverable contract.

On the expiration (or settlement) date of the contract, the long receives a payment if the price of the asset is above the agreed-upon (forward) price; the short receives a payment if the price of the asset is below the contract price.

Terminating a Position Prior to Expiration

A party to a forward contract can **terminate the position** prior to expiration by entering into an opposite forward contract with an expiration date equal to the time remaining on the original contract.

Recall our example and assume that ten days after inception (it was originally a 30-day contract), the 20-day forward price of a $1,000 face value, 90-day T-bill is $992. The short, expecting the price to be even higher by the delivery date, wishes to terminate the contract. Since the short is obligated to sell the T-bill 20 days in the future, he can effectively exit the contract by entering into a new (20-day) forward contract to buy an identical T-bill (a long position) at the current forward price of $992.

The position of the original short now is two-fold, an obligation to sell a T-bill in 20 days for $990 (under the original contract) and an obligation to purchase an identical T-bill in 20 days for $992. He has locked in a $2 loss, but has effectively exited the contract since the amount owed at settlement is $2, regardless of the market price of the T-bill at the settlement date. No matter what the price of a 90-day T-bill is 20 days from now, he has the contractual right and obligation to buy one at $992 and to sell one at $990.

However, if the short's new forward contract is with a different party than the first forward contract, some **credit risk** remains. If the price of the T-bill at the expiration date is above $992, and the counterparty to the second forward contract fails to perform, the short's losses could exceed $2.

An alternative is to enter into the second (offsetting) contract with the same party as the original contract. This would avoid credit risk since the short could make a $2 payment to the counterparty at contract expiration, the amount of his net exposure. In fact, if the original counterparty were willing to take the short position in the second (20-day) contract at the $992 price, a payment of the present value of the $2 (discounted for the 20 days until the settlement date) would be an equivalent transaction. The original counterparty would be willing to allow termination of the original contract for an immediate payment of that amount.

If the original counterparty requires a payment larger than the present value of $2 to exit the contract, the short must weight this additional cost to exit the contract against the default risk he bears by entering into the offsetting contract with a different counterparty at a forward price of $992.

LOS 61.c: Distinguish between a dealer and an end user of a forward contract.

CFA® Program Curriculum, Volume 6, page 30

The **end user of a forward contract** is typically a corporation, government unit, or nonprofit institution that has existing risk they wish to avoid by locking in the future price of an asset. A U.S. corporation that has an obligation to make a payment in Euros 60 days from now can eliminate its exchange rate risk by entering into a forward contract to purchase the required amount of Euros for a certain dollar-denominated payment with a settlement date 60 days in the future.

Dealers are often banks, but can also be nonbank financial institutions such as securities brokers. Ideally, dealers will balance their overall long positions with their overall short positions by entering forward contracts with end users who have opposite existing risk exposures. A dealer's quote desk will quote a buying price (at which they will assume a long position) and a slightly higher selling price (at which they will assume a short position). The bid/ask spread between the two is the dealer's compensation for administrative costs as well as bearing default risk and any asset price risk from unbalanced (unhedged) positions. Dealers will also enter into contracts with other dealers to hedge a net long or net short position.

LOS 61.d: Describe the characteristics of equity forward contracts and forward contracts on zero-coupon and coupon bonds.

CFA® Program Curriculum, Volume 6, page 32

Equity forward contracts where the underlying asset is a single stock, a portfolio of stocks, or a stock index, work in much the same manner as other forward contracts. An investor who wishes to sell 10,000 shares of IBM stock 90 days from now and wishes to avoid the uncertainty about the stock price on that date, could do so by taking a short position in a forward contract covering 10,000 IBM shares. (We will leave the motivation for this and the pricing of such a contract aside for now.)

A dealer might quote a price of $100 per share, agreeing to pay $1 million for the 10,000 shares 90 days from now. The contract may be deliverable or settled in cash as described above. The stock seller has locked in the selling price of the shares and will get no more if the price (in 90 days) is actually higher, and will get no less if the price actually lower.

A portfolio manager who wishes to sell a portfolio of several stocks 60 days from now can similarly request a quote, giving the dealer the company names and the number of shares of each stock in the portfolio. The only difference between this type of forward contract and several forward contracts each covering a single stock, is that the pricing would be better (a higher total price) for the portfolio because overall administration/origination costs would be less for the portfolio forward contract.

A forward contract on a stock index is similar except that the contract will be based on a notional amount and will very likely be a cash-settlement contract.

Example: Equity index forward contracts

A portfolio manager desires to generate $10 million 100 days from now from a portfolio that is quite similar in composition to the S&P 100 index. She requests a quote on a short position in a 100-day forward contract based on the index with a notional amount of $10 million and gets a quote of 525.2. If the index level at the settlement date is 535.7, calculate the amount the manager will pay or receive to settle the contract.

Answer:

The actual index level is 2% *above* the contract price, or:

$$535.7 / 525.2 - 1 = 0.02 = 2\%$$

As the short party, the portfolio manager must pay 2% of the $10 million notional amount, $200,000, to the long.

Alternatively, if the index were 1% below the contract level, the portfolio manager would receive a payment from the long of $100,000, which would approximately offset any decrease in the portfolio value.

Dividends are usually not included in equity forward contracts, as the uncertainty about dividend amounts and payment dates is small compared to the uncertainty about future equity prices. Since forward contracts are custom instruments, the parties could specify a total return value (including dividends) rather than simply the index value. This would effectively remove dividend uncertainty as well.

Forward Contracts on Zero-Coupon and Coupon Bonds

Forward contracts on short-term, zero-coupon bonds (T-bills in the United States) and coupon interest-paying bonds are quite similar to those on equities. However, while equities do not have a maturity date, bonds do, and the forward contract must settle before the bond matures.

As we noted earlier, T-bill prices are often quoted as a percentage discount from face value. The percentage discount for T-bills is annualized so that a 90-day T-bill quoted at a 4% discount will be priced at a $(90 / 360) \times 4\% = 1\%$ discount from face value. This is equivalent to a price quote of $(1 - 0.01) \times \$1,000 = \$990$ per $1,000 of face value.

Example: Bond forwards

A forward contract covering a $10 million face value of T-bills that will have 100 days to maturity at contract settlement is priced at 1.96 on a discount yield basis. Compute the dollar amount the long must pay at settlement for the T-bills.

Answer

The 1.96% annualized discount must be "unannualized" based on the 100 days to maturity.

$0.0196 \times (100 / 360) = 0.005444$ is the actual discount.

The dollar settlement price is $(1 - 0.005444) \times \$10$ million = $9,945,560.

Please note that when market interest rates increase, discounts increase, and T-bill prices fall. A long, who is obligated to purchase the bonds, will have losses on the forward contract when interest rates rise, and gains on the contract when interest rates fall. The outcomes for the short will be opposite.

The price specified in forward contracts on coupon-bearing bonds is typically stated as a yield to maturity as of the settlement date, exclusive of accrued interest. If the contract is on bonds with the possibility of default, there must be provisions in the contract to define default and specify the obligations of the parties in the event of default. Special provisions must also be included if the bonds have embedded options such as call features or conversion features. Forward contracts can be constructed covering individual bonds or portfolios of bonds.

LOS 61.e: Describe the characteristics of the Eurodollar time deposit market, and define LIBOR and Euribor.

CFA® Program Curriculum, Volume 6, page 36

Eurodollar deposit is the term for deposits in large banks outside the United States denominated in U.S. dollars. The lending rate on dollar-denominated loans between banks is called the London Interbank Offered Rate (LIBOR). It is quoted as an annualized rate based on a 360-day year. In contrast to T-bill discount yields, LIBOR is an add-on rate, like a yield quote on a short-term certificate of deposit. LIBOR is used as a reference rate for floating rate U.S. dollar-denominated loans worldwide.

Example: LIBOR-based loans

Compute the amount that must be repaid on a \$1 million loan for 30 days if 30-day LIBOR is quoted at 6%.

Answer:

The add-on interest is calculated as \$1 million × 0.06 × (30 / 360) = \$5,000. The borrower would repay \$1,000,000 + \$5,000 = \$1,005,000 at the end of 30 days.

LIBOR is published daily by the British Banker's Association and is compiled from quotes from a number of large banks; some are large multinational banks based in other countries that have London offices.

There is also an equivalent Euro lending rate called Euribor, or Europe Interbank Offered Rate. Euribor, established in Frankfurt, is published by the European Central Bank.

The floating rates are for various periods and are quoted as such. For example, the terminology is 30-day LIBOR (or Euribor), 90-day LIBOR, and 180-day LIBOR, depending on the term of the loan. For longer-term floating-rate loans, the interest rate is reset periodically based on the then-current LIBOR for the relevant period.

LOS 61.f: Describe forward rate agreements (FRAs) and calculate the gain/loss on a FRA.

LOS 61.g: Calculate and interpret the payoff of a FRA and explain each of the component terms of the payoff formula.

CFA® Program Curriculum, Volume 6, page 35

A **forward rate agreement** (FRA) can be viewed as a forward contract to borrow/lend money at a certain rate at some future date. In practice, these contracts settle in cash, but no actual loan is made at the settlement date. This means that the creditworthiness of the parties to the contract need not be considered in the forward interest rate, so an essentially riskless rate, such as LIBOR, can be specified in the contract. (The parties to the contract may still be exposed to default risk on the amount owed at settlement.)

The long position in an FRA is the party that would borrow the money (long the loan with the contract price being the interest rate on the loan). If the floating rate at contract expiration (LIBOR or Euribor) is above the rate specified in the forward agreement, the long position in the contract can be viewed as the right to borrow at below market rates and the long will receive a payment. If the reference rate at the expiration date is below the contract rate, the short will receive a cash payment from the long. (The right to lend at rates *higher than* market rates would have a positive value.)

To calculate the cash payment at settlement for a forward rate agreement, we need to calculate the value as of the settlement date of making a loan at a rate that is either above or below the market rate. Since the interest savings would come at the end of the loan period, the cash payment at settlement of the forward is the present value of the interest savings. We need to calculate the discounted value at the settlement date of the interest savings or excess interest at the end of the loan period. An example will illustrate the calculation of the payment at expiration and some terminology of FRAs.

Example: FRAs

Consider an FRA that:

- Expires/settles in 30 days.
- Is based on a notional principal amount of $1 million.
- Is based on 90-day LIBOR.
- Specifies a forward rate of 5%.

Assume that the actual 90-day LIBOR 30-days from now (at expiration) is 6%. Compute the cash settlement payment at expiration, and identify which party makes the payment.

Answer:

If the long could borrow at the contract rate of 5%, rather than the market rate of 6%, the interest saved on a 90-day $1 million loan would be:

$$(0.06 - 0.05)(90 / 360) \times 1 \text{ million} = 0.0025 \times 1 \text{ million} = \$2{,}500$$

The $2,500 in interest savings would not come until the end of the 90-day loan period. The value at settlement is the present value of these savings. The correct discount rate to use is the actual rate at settlement, 6%, not the contract rate of 5%.

The payment at settlement from the short to the long is:

$$\frac{2{,}500}{1+\left[(0.06) \times (90/360)\right]} = \$2{,}463.05$$

In doing the calculation of the settlement payment, remember that the term of the FRA and the term of the underlying "loan" need not be the same and are *not* interchangeable. While the settlement date can be any future date, in practice it is usually some multiple of 30 days. The specific market rate on which we calculate the value of the contract will typically be similar, 30-day, 60-day, 90-day, or 180-day LIBOR. If we describe an FRA as a 60-day FRA on 90-day LIBOR, settlement or expiration is 60 days from now and the payment at settlement is based on 90-day LIBOR 60 days from now. Such an FRA could be quoted in (30-day) months, and would be described as a 2-by-5 FRA (or 2 × 5 FRA). The 2 refers to the number of months until contract expiration and the 5 refers to the total time until the end of the interest rate period (2 + 3 = 5).

The general formula for the payment to the long at settlement is:

$$(\text{notional principal})\frac{(\text{floating} - \text{forward})\left(\frac{\text{days}}{360}\right)}{1 + \left[(\text{floating})\left(\frac{\text{days}}{360}\right)\right]}$$

where:
days = number of days in the loan term

The numerator is the interest savings in percent, and the denominator is the discount factor.

Note that if the *floating* rate underlying the agreement turns out to be below the *forward* rate specified in the contract, the numerator in the formula is negative and the short receives a payment from the long.

FRAs for non-standard periods (e.g., a 45-day FRA on 132-day LIBOR) are termed off-the-run FRAs.

LOS 61.h: Describe the characteristics of currency forward contracts.

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Under the terms of a **currency forward contract**, one party agrees to exchange a certain amount of one currency for a certain amount of another currency at a future date. This type of forward contract in practice will specify an exchange rate at which one party can buy a fixed amount of the currency underlying the contract. If we need to exchange 10 million Euros for U.S. dollars 60 days in the future, we might receive a quote of USD0.95. The forward contract specifies that we (the long) will purchase USD9.5 million for EUR10 million at settlement. Currency forward contracts can be deliverable or settled in cash. As with other forward contracts, the cash settlement amount is the amount necessary to compensate the party who would be disadvantaged by the actual change in market rates as of the settlement date. An example will illustrate this.

Example: Currency forwards

Gemco expects to receive EUR50 million three months from now and enters into a cash settlement currency forward to exchange these euros for U.S. dollars at USD1.23 per euro. If the market exchange rate is USD1.25 per euro at settlement, what is the amount of the payment to be received or paid by Gemco?

Answer:

Under the terms of the contract Gemco would receive:

$$\text{EUR50 million} \times \frac{\text{USD}}{\text{EUR}} 1.23 = \text{USD61.5 million}$$

Without the forward contract, Gemco would receive:

$$\text{EUR50 million} \times \frac{\text{USD}}{\text{EUR}} 1.25 = \text{USD62.5 million}$$

The counterparty would be disadvantaged by the difference between the contract rate and the market rate in an amount equal to the advantage that would have accrued to Gemco had they not entered into the currency forward.

Gemco must make a payment of USD1.0 million to the counterparty.

A direct calculation of the value of the long (USD) position at settlement is:

$$\left(\frac{\text{USD}}{\text{EUR}}1.23 - \frac{\text{USD}}{\text{EUR}}1.25\right) \times \text{EUR50 million} = -\text{USD1.0 million}$$

KEY CONCEPTS

LOS 61.a

A deliverable forward contract on an asset specifies that the long (the buyer) will pay a certain amount at a future date to the short, who will deliver a certain amount of an asset.

Default risk in a forward contract is the risk that the other party to the contract will not perform at settlement, because typically no money changes hands at the initiation of the contract.

LOS 61.b

A forward contract with cash settlement does not require delivery of the underlying asset, but a cash payment at the settlement date from one counterparty to the other, based on the contract price and the market price of the asset at settlement.

Early termination of a forward contract can be accomplished by entering into a new forward contract with the opposite position, at the then-current expected forward price. This early termination will fix the amount of the gain or loss at the settlement date. If this new forward is with a different counterparty than the original, there is credit or default risk to consider since one of the two counterparties may fail to honor its obligation under the forward contract.

LOS 61.c

An end user of a forward contract is most often a corporation hedging an existing risk.

Forward dealers, large banks, or brokerages originate forward contracts and take the long side in some contracts and the short side in others, with a spread in pricing to compensate them for actual costs, bearing default risk, and any unhedged price risk they must bear.

LOS 61.d

An equity forward contract may be on a single stock, a customized portfolio, or an equity index, and is used to hedge the risk of equity prices at some future date.

- Equity forward contracts can be written on a total return basis (including dividends), but are typically based solely on an index value.
- Index forwards settle in cash based on the notional amount and the percentage difference between the index value in the forward contract and the actual index level at settlement.

Forward contracts in which bonds are the underlying asset may be quoted in terms of the discount on zero-coupon bonds (e.g., T-bills) or in terms of the yield to maturity on coupon bonds. Forwards on corporate bonds must contain special provisions to deal with the possibility of default as well as with any call or conversion features. Forward contracts may also be written on portfolios of fixed income securities or on bond indexes.

LOS 61.e

Eurodollar time deposits are USD-denominated short-term unsecured loans to large money-center banks outside the United States.

The London Interbank Offered Rate (LIBOR) is an international reference rate for Eurodollar deposits and is quoted for 30-day, 60-day, 90-day, 180-day, or 360-day (1-year) terms.

Euribor is the equivalent for short-term Euro-denominated bank deposits (loans to banks).

For both LIBOR and Euribor, rates are expressed as annual rates and actual interest is based on the loan term as a proportion of a 360-day year.

LOS 61.f

Forward rate agreements (FRAs) serve to hedge the uncertainty about short-term rates (e.g., 30- or 90-day LIBOR) that will prevail in the future. If rates rise, the long receives a payment at settlement. The short receives a payment if the specified rate falls to a level below the contract rate.

LOS 61.g

The payment to the long at settlement on an FRA is:

$$\text{notional ptincipal amount}\left\{\frac{(\text{reference rate at settlement} - \text{FRA rate})\left[\dfrac{\text{days in loan term}}{360}\right]}{1+\text{reference rate at settlement}\times\left[\dfrac{\text{days in loan term}}{360}\right]}\right\}$$

The numerator is the difference between the rate on a loan for the specified period at the forward contract rate and the rate at settlement, and the denominator is to discount this interest differential back to the settlement date at the market rate at settlement.

LOS 61.h

Currency forward contracts specify that one party will deliver a certain amount of one currency at the settlement date in exchange for a certain amount of another currency.

Under cash settlement, a single cash payment is made at settlement based on the difference between the exchange rate fixed in the contract and the market exchange rate at the settlement date.

Concept Checkers

1. The short in a deliverable forward contract:
   A. has no default risk.
   B. is obligated to deliver the specified asset.
   C. makes a cash payment to the long at settlement.

2. On the settlement date of a forward contract:
   A. the short may be required to sell the asset.
   B. the long must sell the asset or make a cash payment.
   C. at least one party must make a cash payment to the other.

3. Which of the following statements regarding early termination of a forward contract is *most accurate*?
   A. A party who enters into an offsetting contract to terminate has no risk.
   B. A party who terminates a forward contract early must make a cash payment.
   C. Early termination through an offsetting transaction with the original counterparty eliminates default risk.

4. A dealer in the forward contract market:
   A. cannot be a bank.
   B. may enter into a contract with another dealer.
   C. gets a small payment for each contract at initiation.

5. Which of the following statements regarding equity forward contracts is *least accurate*?
   A. Equity forwards may be settled in cash.
   B. Dividends are never included in index forwards.
   C. A short position in an equity forward could not hedge the risk of a purchase of that equity in the future.

6. Which of the following statements regarding forward contracts on 90-day T-bills is *most accurate*?
   A. The face value must be paid by the long at settlement.
   B. There is no default risk on these forwards because T-bills are government-backed.
   C. If short-term yields increase unexpectedly after contract initiation, the short will profit on the contract.

7. A Eurodollar time deposit:
   A. is priced on a discount basis.
   B. may be issued by a Japanese bank.
   C. is a certificate of deposit denominated in Euros.

8. One difference between LIBOR and Euribor is that:
   A. LIBOR is for London deposits.
   B. they are for different currencies.
   C. LIBOR is slightly higher due to default risk.

9. Which of the following statements regarding a LIBOR-based FRA is *most accurate*?
   A. The short will settle the contract by making a loan.
   B. FRAs can be based on interest rates for 30-, 60-, or 90-day periods.
   C. If LIBOR increases unexpectedly over the contract term, the long will be required to make a cash payment at settlement.

10. Consider a $2 million FRA with a contract rate of 5% on 60-day LIBOR. If 60-day LIBOR is 6% at settlement, the long will:
    A. pay $3,333.
    B. receive $3,300.
    C. receive $3,333.

11. Party A has entered a currency forward contract to purchase €10 million at an exchange rate of $0.98 per euro. At settlement, the exchange rate is $0.97 per euro. If the contract is settled in cash, Party A will:
    A. make a payment of $100,000.
    B. receive a payment of $100,000.
    C. receive a payment of $103,090.

12. If the quoted discount yield on a 128-day, $1 million T-bill decreases from 3.15% to 3.07%, how much has the holder of the T-bill gained or lost?
    A. Lost $284.
    B. Gained $284.
    C. Gained $800.

13. 90-day LIBOR is quoted as 3.58%. How much interest would be owed at maturity for a 90-day loan of $1.5 million at LIBOR + 1.3%?
    A. $17,612.
    B. $18,300.
    C. $32,925.

14. A company treasurer needs to borrow 10 million euros for 180 days, 60 days from now. The type of FRA and the position he should take to hedge the interest rate risk of this transaction are:

	FRA	Position
A.	2 × 6	Short
B.	2 × 8	Long
C.	2 × 8	Short

Answers – Concept Checkers

1. B The short in a forward contract is obligated to deliver the specified asset at the contract price on the settlement date. Either party may have default risk if there is any probability that the counterparty may not perform under the terms of the contract.

2. A A forward contract may call for settlement in cash or for delivery of the asset. Under a deliverable contract, the short is required to deliver the asset at settlement, not to make a cash payment.

3. C Terminating a forward contract early by entering into an offsetting forward contract with a different counterparty exposes a party to default risk. If the offsetting transaction is with the original counterparty, default risk is eliminated. No cash payment is required if an offsetting contract is used for early termination.

4. B Forward contracts dealers are commonly banks and large brokerage houses. They frequently enter into forward contracts with other dealers to offset long or short exposure. No payment is typically made at contract initiation.

5. B Index forward contracts may be written as total return contracts, which include dividends. Contracts may be written to settle in cash, or to be deliverable. A *long* position is used to reduce the price risk of an expected future purchase.

6. C When short-term rates increase, T-bill prices fall and the short position will profit. The price of a T-bill prior to maturity is always less than its face value. The deliverable security is a T-bill with 90 days to maturity. There is default risk on the *forward*, even though the underlying asset is considered risk free.

7. B Eurodollar time deposits are U.S. dollar-denominated accounts with banks outside the United States and are quoted as an add-on yield rather than on a discount basis.

8. B LIBOR is for U.S. dollar-denominated accounts while Euribor is for euro-denominated accounts. Neither is location-specific. Differences in these rates are due to the different currencies involved, not differences in default risk.

9. B A LIBOR-based contract can be based on LIBOR for various terms. They are settled in cash. The long will receive a payment when LIBOR is higher than the contract rate at settlement.

10. B $(0.06 - 0.05) \times (60 / 360) \times \$2 \text{ million} \times 1 / (1 + 0.06 / 6) = \$3,300.33$.

11. A $(\$0.98 - \$0.97) \times 10 \text{ million} = \$100,000$ loss. The long, Party A, is obligated to buy euros at \$0.98 when they are only worth \$0.97 and must pay $\$0.01 \times 10 \text{ million} = \$100,000$.

12. B The actual discount has decreased by:

$$(0.0315-0.0307)\times\frac{128}{360}=0.0284\% \text{ of } \$1{,}000{,}000, \text{ or } \$284.$$

A decrease in the discount is an increase in value.

13. B $(0.0358 + 0.013)\left(\frac{90}{360}\right)1.5 \text{ million} = \$18{,}300$. Both LIBOR and any premium to LIBOR are quoted as annualized rates.

14. B This requires a long position in a 2 × 8 FRA.

The following is a review of the Derivatives principles designed to address the learning outcome statements set forth by CFA Institute. This topic is also covered in:

FUTURES MARKETS AND CONTRACTS

Study Session 17

EXAM FOCUS

Candidates should focus on the terminology of futures markets, how futures differ from forwards, the mechanics of margin deposits, and the process of marking to market. Other important concepts here include limit price moves, delivery options, and the characteristics of the basic types of financial futures contracts. Learn the ways a futures position can be terminated prior to contract expiration and understand how cash settlement is accomplished by the final mark-to-market at contract expiration.

LOS 62.a: Describe the characteristics of futures contracts.

LOS 62.b: Compare futures contracts and forward contracts.

CFA® Program Curriculum, Volume 6, page 43

Futures contracts are very much like the forward contracts we learned about in the previous topic review. They are *similar* in that both:

- Can be either deliverable or cash settlement contracts.
- Are priced to have zero value at the time an investor enters into the contract.

Futures contracts *differ* from forward contracts in the following ways:

- Futures contracts trade on organized exchanges. Forwards are private contracts and do not trade.
- Futures contracts are highly standardized. Forwards are customized contracts satisfying the needs of the parties involved.
- A single clearinghouse is the counterparty to all futures contracts. Forwards are contracts with the originating counterparty.
- The government regulates futures markets. Forward contracts are usually not regulated.

Characteristics of Futures Contracts

Standardization. A major difference between forwards and futures is that futures contracts have standardized contract terms. Futures contracts specify the quality and quantity of goods that can be delivered, the delivery time, and the manner of delivery. The exchange also sets the minimum price fluctuation (which is called the tick size). For example, the basic price movement, or tick, for a 5,000-bushel grain contract is a quarter of a point (1 point = $0.01) per bushel, or $12.50 per contract. Contracts also have a daily price limit, which sets the maximum price movement allowed in a single day. For example, wheat cannot move more than $0.20 from its close the preceding day.

The maximum price limits expand during periods of high volatility and are not in effect during the delivery month. The exchange also sets the trading times for each contract.

It would appear that these rules would restrict trading activity, but in fact, they stimulate trading. Why? Standardization tells traders exactly what is being traded and the conditions of the transaction. *Uniformity promotes market liquidity.*

The purchaser of a futures contract is said to have gone long or taken a *long position*, while the seller of a futures contract is said to have gone short or taken a *short position*. For each contract traded, there is a buyer and a seller. The long has contracted to buy the asset at the contract price at contract expiration, and the short has an obligation to sell at that price. Futures contracts are used by *speculators* to gain exposure to changes in the price of the asset underlying a futures contract. A *hedger*, in contrast, will use futures contracts to reduce exposure to price changes in the asset (hedge their asset price risk). An example is a wheat farmer who sells wheat futures to reduce the uncertainty about the price of wheat at harvest time.

Clearinghouse. Each exchange has a *clearinghouse*. The clearinghouse guarantees that traders in the futures market will honor their obligations. The clearinghouse does this by splitting each trade once it is made and acting as the opposite side of each position. The clearinghouse acts as the buyer to every seller and the seller to every buyer. By doing this, the clearinghouse allows either side of the trade to reverse positions at a future date without having to contact the other side of the initial trade. This allows traders to enter the market knowing that they will be able to reverse their position. Traders are also freed from having to worry about the counterparty defaulting since the counterparty is now the clearinghouse. In the history of U.S. futures trading, the clearinghouse has never defaulted on a trade.

Professor's Note: The terminology is that you "bought" bond futures if you entered into the contract with the long position. In my experience, this terminology has caused confusion for many candidates. You don't purchase the contract, you enter into it. You are contracting to buy an asset on the long side. "Buy" means take the long side, and "sell" means take the short side in futures.

LOS 62.c: Distinguish between margin in the securities markets and margin in the futures markets, and explain the role of initial margin, maintenance margin, variation margin, and settlement in futures trading.

CFA® Program Curriculum, Volume 6, page 48

In securities markets, margin on a stock or bond purchase is a percentage of the market value of the asset. Initially, 50% of the stock purchase amount may be borrowed, and the remaining amount, the equity in the account, must be paid in cash. There is interest charged on the borrowed amount, the margin loan. The margin percentage, the percent of the security value that is owned, will vary over time and must be maintained at some minimum percentage of market value.

In the futures markets, margin is a performance guarantee. It is money deposited by both the long and the short. There is no loan involved and, consequently, no interest charges.

Each futures exchange has a clearinghouse. To safeguard the clearinghouse, the exchange requires traders to post margin and settle their accounts on a daily basis. Before trading, the trader must deposit funds (called margin) with a broker (who, in turn, will post margin with the clearinghouse).

In securities markets, the cash deposited is paid to the seller of the security, with the balance of the purchase price provided by the broker. This is why the unpaid balance is a loan, with interest charged to the buyer who purchased on margin.

Initial margin is the money that must be deposited in a futures account before any trading takes place. It is set for each type of underlying asset. Initial margin per contract is relatively low and equals about one day's maximum price fluctuation on the total value of the contract's underlying asset.

Maintenance margin is the amount of margin that must be maintained in a futures account. If the margin balance in the account falls below the maintenance margin due to a change in the contract price for the underlying asset, additional funds must be deposited to bring the margin balance back up to the initial margin requirement.

This is in contrast to equity account margins, which require investors only to bring the margin percentage up to the maintenance margin, not back to the initial margin level.

Variation margin is the funds that must be deposited into the account to bring it back to the initial margin amount. If account margin exceeds the initial margin requirement, funds can be withdrawn or used as initial margin for additional positions.

The **settlement price** is analogous to the closing price for a stock but is not simply the price of the last trade. It is an average of the prices of the trades during the last period of trading, called the closing period, which is set by the exchange. This feature of the settlement price prevents manipulation by traders. The settlement price is used to make margin calculations at the end of each trading day.

Initial and minimum margins in securities accounts are set by the Federal Reserve, although brokerage houses can require more. Initial and maintenance margins in the futures market are set by the clearinghouse and are based on historical daily price volatility of the underlying asset since margin is resettled daily in futures accounts. Margin in futures accounts is typically *much lower* as a percentage of the value of the assets covered by the futures contract. This means that the leverage, based on the actual cash required, is much higher for futures accounts.

How a Futures Trade Takes Place

In contrast to forward contracts in which a bank or brokerage is usually the counterparty to the contract, there is a buyer and a seller on each side of a futures trade. The futures exchange selects the contracts that will trade. The asset, the amount of the asset, and the settlement/delivery date are standardized in this manner (e.g., a June futures contract on 90-day T-bills with a face amount of $1 million). Each time there is a trade, the delivery price for that contract is the equilibrium price at that point in time, which depends on supply (by those wishing to be short) and demand (by those wishing to be long).

The mechanism by which supply and demand determine this equilibrium is open outcry at a particular location on the exchange floor called a *pit*. Each trade is reported to the exchange so that the equilibrium price, at any point in time, is known to all traders.

LOS 62.d: Describe price limits and the process of marking to market, and calculate and interpret the margin balance, given the previous day's balance and the change in the futures price.

CFA® Program Curriculum, Volume 6, page 48

Many futures contracts have **price limits**, which are exchange-imposed limits on how much the contract price can change from the previous day's settlement price. Exchange members are prohibited from executing trades at prices outside these limits. If the (equilibrium) price at which traders would willingly trade is above the upper limit or below the lower limit, trades cannot take place.

Consider a futures contract that has daily price limits of two cents and settled the previous day at $1.04. If, on the following trading day, traders wish to trade at $1.07 because of changes in market conditions or expectations, no trades will take place. The settlement price will be reported as $1.06 (for the purposes of marking-to-market). The contract will be said to have made a **limit move**, and the price is said to be **limit up** (from the previous day). If market conditions had changed such that the price at which traders are willing to trade is below $1.02, $1.02 will be the settlement price, and the price is said to be **limit down**. If trades cannot take place because of a limit move, either up or down, the price is said to be **locked limit** since no trades can take place and traders are locked into their existing positions.

Marking-to-market is the process of adjusting the margin balance in a futures account each day for the change in the value of the contract assets from the previous trading day, based on the new settlement price.

The futures exchanges can require a mark-to-market more frequently (than daily) under extraordinary circumstances.

Computing the Margin Balance

Example: Margin balance

Consider a long position of five July wheat contracts, each of which covers 5,000 bushels. Assume that the contract price is $2.00 and that each contract requires an initial margin deposit of $150 and a maintenance margin of $100. The total initial margin required for the 5-contract trade is $750. The maintenance margin for the account is $500. Compute the margin balance for this position after a 2-cent decrease in price on Day 1, a 1-cent increase in price on Day 2, and a 1-cent decrease in price on Day 3.

Answer:

Each contract is for 5,000 bushels so that a price change of $0.01 per bushel changes the contract value by $50, or $250 for the five contracts: (0.01)(5)(5,000) = $250.00.

The following figure illustrates the change in the margin balance as the price of this contract changes each day. Note that the initial balance is the initial margin requirement of $750 and that the required deposit is based on the previous day's price change.

Margin Balances

Day	*Required Deposit*	*Price/Bushel*	*Daily Change*	*Gain/Loss*	*Balance*
0 (Purchase)	$750	$2.00	0	0	$750
1	0	$1.98	–$0.02	–$500	$250
2	$500	$1.99	+$0.01	+$250	$1,000
3	0	$1.98	–$0.01	–$250	$750

At the close on Day 1, the margin balance has gone below the minimum or maintenance margin level of $500. Therefore, a deposit of $500 is required to bring the margin back to the initial margin level of $750. We can interpret the margin balance at any point as the amount the investor would realize if the position were closed out by a reversing trade at the most recent settlement price used to calculate the margin balance.

LOS 62.e: Describe how a futures contract can be terminated at or prior to expiration.

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There are **four ways to terminate a futures contract**:

1. A short can terminate the contract by delivering the goods, and a long can terminate the contract by accepting delivery and paying the contract price to the short. This is called **delivery**. The location for delivery (for physical assets), terms of delivery, and details of exactly what is to be delivered are all specified in the contract. Deliveries represent less than 1% of all contract terminations.

2. In a **cash-settlement contract**, delivery is not an option. The futures account is marked-to-market based on the settlement price on the last day of trading.

3. You may make a **reverse**, or **offsetting**, trade in the futures market. This is similar to the way we described exiting a forward contract prior to expiration. With futures, however, the other side of your position is held by the clearinghouse—if you make an exact opposite trade (maturity, quantity, and good) to your current position, the clearinghouse will net your positions out, leaving you with a zero balance. This is how most futures positions are settled. The contract price can differ between the two contracts. If you initially are long one contract at $370 per ounce of gold and subsequently sell (take the short position in) an identical gold contract when the price is $350/oz., $20 times the number of ounces of gold specified in the contract will be deducted from the margin deposit(s) in your account. The sale of the futures contract ends the exposure to future price fluctuations on the first contract. Your position has been *reversed*, or **closed out**, by a *closing* trade.

4. A position may also be settled through an **exchange for physicals**. Here, you find a trader with an opposite position to your own and deliver the goods and settle up between yourselves, off the floor of the exchange (called an ex-pit transaction). This is the sole exception to the federal law that requires that all trades take place on the floor of the exchange. You must then contact the clearinghouse and tell them what happened. An exchange for physicals differs from a delivery in that the traders actually exchange the goods, the contract is not closed on the floor of the exchange, and the two traders privately negotiate the terms of the transaction. Regular delivery involves only one trader and the clearinghouse.

Delivery Options in Futures Contracts

Some futures contracts grant **delivery options** to the short; options on what, where, and when to deliver. Some Treasury bond contracts give the short a choice of several bonds that are acceptable to deliver and options as to when to deliver during the expiration month. Physical assets, such as gold or corn, may offer a choice of delivery locations to the short. These options can be of significant value to the holder of the short position in a futures contract.

LOS 62.f: Describe the characteristics of the following types of futures contracts: Treasury bill, Eurodollar, Treasury bond, stock index, and currency.

CFA® Program Curriculum, Volume 6, page 57

Let's introduce financial futures by first examining the mechanics of a T-bill futures contract. **Treasury bill futures** contracts are based on a $1 million face value 90-day (13-week) T-bill and settle in cash. The price quotes are 100 minus the annualized discount in percent on the T-bills.

A price quote of 98.52 represents an annualized discount of 1.48%, an actual discount from face of 0.0148 × (90 / 360) = 0.0037, and a delivery price of (1 – 0.0037) × 1 million = $996,300.

T-bill futures contracts are not as important as they once were. Their prices are heavily influenced by U.S. Federal Reserve operations and overall monetary policy. T-bill futures have lost importance in favor of Eurodollar futures contracts, which represent a more free-market and more global measure of short-term interest rates to top quality borrowers for U.S. dollar-denominated loans.

Eurodollar futures are based on 90-day LIBOR, which is an add-on yield, rather than a discount yield. By convention, however, the price quotes follow the same convention as T-bills and are calculated as (100 – annualized LIBOR in percent). These contracts settle in cash, and the minimum price change is one *tick*, which is a price change of 0.0001 = 0.01%, representing $25 per $1 million contract. A quote of 97.60 corresponds to an annualized LIBOR of (100 – 97.6) = 2.4% and an effective 90-day yield of 2.4 / 4 = 0.6%.

Professor's Note: Eurodollar futures are priced such that the long position gains value when interest rates decrease. This is different from forward rate agreements and interest rate call options, where the long position gains when interest rates increase.

One of the first things a new T-bill futures trader learns is that each change in price of 0.01 in the price of a T-bill futures contract is worth $25. If you took a long position at 98.52 and the price fell to 98.50, your loss is $50 per contract. Because Eurodollar contracts on 90-day LIBOR are the same size and priced in a similar fashion, a price change of 0.01 represents a $25 change in value for these as well.

Treasury bond futures contracts:

- Are traded for Treasury bonds with maturities greater than 15 years.
- Are a deliverable contract.
- Have a face value of $100,000.
- Are quoted as a percent and fractions of 1% (measured in 1/32nds) of face value.

The short in a Treasury bond futures contract has the option to deliver any of several bonds that will satisfy the delivery terms of the contract. This is called a delivery option and is valuable to the short because at expiration, one particular Treasury bond will be the **cheapest-to-deliver** bond.

Each bond is given a *conversion factor*, which is used to adjust the long's payment at delivery so that the more valuable bonds receive a higher payment. These factors are multipliers for the futures price at settlement. The long pays the futures price at expiration times the conversion factor.

Stock index futures. The most popular stock index future is the S&P 500 Index Future that trades in Chicago. Settlement is in cash and is based on a multiplier of 250.

The value of a contract is 250 times the level of the index stated in the contract. With an index level of 1,000, the value of each contract is $250,000. Each index point in the futures price represents a gain or loss of $250 per contract. A long stock index futures position on S&P 500 index futures at 1,051 would show a gain of $1,750 in the trader's account if the index were 1,058 at the settlement date ($250 × 7 = $1,750). A smaller contract is traded on the same index and has a multiplier of 50.

Futures contracts covering several other popular indices are traded, and the pricing and contract valuation are the same, although the multiplier can vary from contract to contract.

Currency futures. The currency futures market is smaller in volume than the forward currency market we described in the previous topic review. In the United States, currency contracts trade on the euro (EUR), Mexican peso (MXP), and yen (JPY), among others. Contracts are set in units of the foreign currency, and the price is stated in USD/unit. The size of the peso contract is MXP500,000, and the euro contract is on EUR125,000. A change in the price of the currency unit of USD0.0001 translates into a gain or loss of USD50 on a MXP500,000 unit contract and USD12.50 on a EUR125,000 unit contract.

KEY CONCEPTS

LOS 62.a

Like forward contracts, futures contracts are most commonly for delivery of commodities and financial assets at a future date and can require delivery or settlement in cash.

LOS 62.b

Compared to forward contracts, futures contracts:
- Are more liquid, trade on exchanges, and can be closed out by an offsetting trade.
- Do not have counterparty risk; the clearinghouse acts as counterparty to each side of the contract.
- Have lower transactions costs.
- Require margin deposits and are marked to market daily.
- Are standardized contracts as to asset quantity, quality, settlement dates, and delivery requirements.

LOS 62.c

Futures margin deposits are not loans, but deposits to ensure performance under the terms of the contract.

Initial margin is the deposit required to initiate a futures position.

Maintenance margin is the minimum margin amount. When margin falls below this amount, it must be brought back up to its initial level by depositing variation margin.

Margin calculations are based on the daily settlement price, the average of the prices for trades during a closing period set by the exchange.

LOS 62.d

Trades cannot take place at prices that differ from the previous day's settlement prices by more than the price limit and are said to be limit down (up) when the new equilibrium price is below (above) the minimum (maximum) price for the day.

Marking-to-market is the process of adding gains to or subtracting losses from the margin account daily, based on the change in settlement prices from one day to the next.

The mark-to-market adjustment either adds the day's gains in contract value to the long's margin balance and subtracts them from the short's margin balance, or subtracts the day's loss in contract value from the long's margin balance and adds them to the short's margin balance.

LOS 62.e

A futures position can be terminated in the following ways:
- An offsetting trade, entering into an opposite position in the same contract.
- Cash payment at expiration (cash-settlement contract).
- Delivery of the asset specified in the contract.
- An exchange for physicals (asset delivery off the exchange).

LOS 62.f

Eurodollar futures contracts are for a face value of $1,000,000, are quoted as 100 minus annualized 90-day LIBOR in percent, and settle in cash.

Treasury bond contracts are for a face value of $100,000, give the short a choice of bonds to deliver, and use conversion factors to adjust the contract price for the bond that is delivered.

Stock index futures have a multiplier that is multiplied by the index to calculate the contract value, and settle in cash.

Currency futures are for delivery of standardized amounts of foreign currency.

CONCEPT CHECKERS

1. Which of the following statements about futures markets is *least accurate*?
   A. Hedgers trade to reduce some preexisting risk exposure.
   B. The clearinghouse guarantees that traders in the futures market will honor their obligations.
   C. If an account rises to or exceeds the maintenance margin, the trader must deposit variation margin.

2. The daily process of adjusting the margin in a futures account is called:
   A. variation margin.
   B. marking-to-market.
   C. maintenance margin.

3. A trader buys (takes a long position in) a Eurodollar futures contract ($1 million face value) at 98.14 and closes it out at a price of 98.27. On this contract, the trader has:
   A. lost $325.
   B. gained $325.
   C. gained $1,300.

4. In the futures market, a contract does not trade for two days because trades are not permitted at the equilibrium price. The market for this contract is:
   A. limit up.
   B. limit down.
   C. locked limit.

5. The existence of a delivery option with respect to Treasury bond futures means that the:
   A. short can choose which bond to deliver.
   B. short has the option to settle in cash or by delivery.
   C. long chooses which of a number of bonds will be delivered.

6. Assume the holder of a long futures position negotiates privately with the holder of a short futures position to accept delivery to close out both the long and short positions. Which of the following statements about the transaction is *most accurate*? The transaction is:
   A. also known as delivery.
   B. also known as an exchange for physicals.
   C. the most common way to close a futures position.

7. A conversion factor in a Treasury bond contract is:
   A. used to adjust the number of bonds to be delivered.
   B. multiplied by the face value to determine the delivery price.
   C. multiplied by the futures price to determine the delivery price.

8. Three 125,000 euro futures contracts are sold at a price of $1.0234. The next day the price settles at $1.0180. The mark-to-market for this account changes the previous day's margin by:
   A. +$675.
   B. –$675.
   C. +$2,025.

9. In the futures market, the clearinghouse is *least likely* to:
   A. decide which contracts will trade.
   B. set initial and maintenance margins.
   C. act as the counterparty to every trade.

10. Funds deposited to meet a margin call are termed:
    A. daily margin.
    B. settlement costs.
    C. variation margin.

11. Compared to forward contracts, futures contracts are *least likely* to be:
    A. standardized.
    B. larger in size.
    C. less subject to default risk.

Answers – Concept Checkers

1. C If an account rises to or exceeds the maintenance margin, no payment needs to be made, and the trader has the option to remove the excess funds from the account. Only if an account falls below the maintenance margin does variation margin need to be paid to bring the level of the account back up to the level of the initial margin.

2. B The *process* is called marking-to-market. Variation margin is the funds that must be deposited when marking-to-market draws the margin balance below the maintenance margin.

3. B The price is quoted as 100 minus the annualized discount in percent. Remember that the gains and losses on T-bill and Eurodollar futures are $25 per basis point of the price quote. The price is up 13 ticks, and 13 × $25 is a gain of $325 for a long position.

4. C This describes the situation when the equilibrium price is either above or below the prior day's settle price by more than the permitted (limit) daily price move. We do not know whether it is limit up or limit down.

5. A The short has the option to deliver any of a number of permitted bonds. The delivery price is adjusted by a conversion factor that is calculated for each permitted bond.

6. B When the holder of a long position negotiates directly with the holder of the short position to accept delivery of the underlying commodity to close out both positions, this is called an *exchange for physicals*. (This is a private transaction that occurs *ex-pit* and is one exception to the federal law that all trades take place on the exchange floor.) Note that the exchange for physicals differs from an offsetting trade in which no delivery takes place and also differs from delivery in which the commodity is simply delivered as a result of the futures expiration with no secondary agreement. Most futures positions are settled by an *offsetting trade*.

7. C It adjusts the delivery price based on the futures price at contract expiration.

8. C (1.0234 – 1.0180) × 125,000 × 3 = $2,025. The contracts were sold and the price declined, so the adjustment is an addition to the account margin.

9. A The exchange determines which contracts will trade.

10. C When insufficient funds exist to satisfy margin requirements, a variation margin must be posted.

11. B Size is not one of the things that distinguishes forwards and futures, although the contract size of futures is standardized, whereas forwards are customized for each party.

The following is a review of the Derivatives principles designed to address the learning outcome statements set forth by CFA Institute. This topic is also covered in:

OPTION MARKETS AND CONTRACTS

Study Session 17

EXAM FOCUS

This derivatives review introduces options, describes their terms and trading, and provides derivations of several options valuation results. Candidates should spend some time understanding how the payoffs on several types of options are determined. This includes options on stocks, bonds, stock indices, interest rates, currencies, and futures. The assigned material on establishing upper and lower bounds is extensive, so it should not be ignored. Candidates must learn at least one of the put-call parity relations and how to construct an arbitrage strategy. The notation, formulas, and relations may seem daunting, but if you put in the time to understand what the notation is saying (and why), you can master the important points.

LOS 63.a: Describe call and put options.

CFA® Program Curriculum, Volume 6, page 72

An **option contract** gives its owner the right, but not the legal obligation, to conduct a transaction involving an underlying asset at a predetermined future date (the exercise date) and at a predetermined price (the **exercise price** or **strike price**). Options give the option buyer the right to decide whether or not the trade will eventually take place. The seller of the option has the obligation to perform if the buyer exercises the option.

- The owner of a **call option** has the right to purchase the underlying asset at a specific price for a specified time period.
- The owner of a **put option** has the right to sell the underlying asset at a specific price for a specified time period.

For every owner of an option, there must be a seller. The seller of the option is also called the **option writer**. There are four possible options positions:

1. Long call: the buyer of a call option—has the right to buy an underlying asset.
2. Short call: the writer (seller) of a call option—has the obligation to sell the underlying asset.
3. Long put: the buyer of a put option—has the right to sell the underlying asset.
4. Short put: the writer (seller) of a put option—has the obligation to buy the underlying asset.

To acquire these rights, owners of options must buy them by paying a price called the **option premium** to the seller of the option.

Listed stock option contracts trade on exchanges and are normally for 100 shares of stock. After issuance, stock option contracts are adjusted for stock splits but not cash dividends.

To see how an option contract works, consider the stock of ABC Company. It sells for \$55 and has a call option available on it that sells for a premium of \$10. This call option has an exercise price of \$50 and has an expiration date in five months.

Professor's Note: The option premium is simply the price of the option. Please do not confuse this with the exercise price of the option, which is the price at which the underlying asset will be bought/sold if the option is exercised.

If the ABC call option is purchased for \$10, the buyer can purchase ABC stock from the option seller over the next five months for \$50. The seller, or writer, of the option gets to keep the \$10 premium no matter what the stock does during this time period. If the option buyer exercises the option, the seller will receive the \$50 strike price and must deliver to the buyer a share of ABC stock. If the price of ABC stock falls to \$50 or below, the buyer is not obligated to exercise the option. Note that option holders will only exercise their right to act if it is profitable to do so. The option writer, however, has an obligation to act at the request of the option holder.

A put option on ABC stock is the same as a call option, except the buyer of the put (long position) has the right to sell a share of ABC for \$50 at any time during the next five months. The put writer (short position) has the obligation to buy ABC stock at the exercise price in the event that the option is exercised.

The owner of the option is the one who decides whether or not to exercise the option. If the option has value, the buyer may either exercise the option or sell the option to another buyer in the secondary options market.

LOS 63.b: Distinguish between European and American options.

CFA® Program Curriculum, Volume 6, page 73

American options may be exercised at any time up to and including the contract's expiration date.

European options can be exercised only on the contract's expiration date.

Professor's Note: The name of the option does not imply where the option trades— they are just names.

At expiration, an American option and a European option on the same asset with the same strike price are identical. They may either be exercised or allowed to expire. Before expiration, however, they are different and may have different values, so you must distinguish between the two.

If two options are identical (maturity, underlying stock, strike price, etc.) in all ways, except that one is a European option and the other is an American option, the value of the American option will equal or exceed the value of the European option. Why? The early exercise feature of the American option gives it more flexibility, so it should be worth at least as much and possibly more.

LOS 63.c: Define the concept of moneyness of an option.

CFA® Program Curriculum, Volume 6, page 75

Moneyness refers to whether an option is *in the money* or *out of the money*. If immediate exercise of the option would generate a positive payoff, it is in the money. If immediate exercise would result in a loss (negative payoff), it is out of the money. When the current asset price equals the exercise price, exercise will generate neither a gain nor loss, and the option is *at the money*.

The following describe the conditions for a **call option** to be in, out of, or at the money.

- *In-the-money call options.* If S – X > 0, a call option is in the money. S – X is the amount of the payoff a call holder would receive from immediate exercise, buying a share for *X* and selling it in the market for a greater price *S*.
- *Out-of-the-money call options.* If S – X < 0, a call option is out of the money.
- *At-the-money call options.* If S = X, a call option is said to be at the money.

The following describe the conditions for a **put option** to be in, out of, or at the money.

- *In-the-money put options.* If X – S > 0, a put option is in the money. X – S is the amount of the payoff from immediate exercise, buying a share for *S* and exercising the put to receive *X* for the share.
- *Out-of-the-money put options.* When the stock's price is greater than the strike price, a put option is said to be out of the money. If X – S < 0, a put option is out of the money.
- *At-the-money put options.* If S = X, a put option is said to be at the money.

Example: Moneyness

Consider a July 40 call and a July 40 put, both on a stock that is currently selling for $37/share. Calculate how much these options are in or out of the money.

Professor's Note: A July 40 call is a call option with an exercise price of $40 and an expiration date in July.

Answer:

The call is $3 out of the money because S – X = –$3.00. The put is $3 in the money because X – S = $3.00.

LOS 63.d: Compare exchange-traded options and over-the-counter options.

CFA® Program Curriculum, Volume 6, page 76

Exchange-traded or **listed options** are regulated, standardized, liquid, and backed by the Options Clearing Corporation for Chicago Board Options Exchange transactions. Most exchange-listed options have expiration dates within two to four months of the current date. Exchanges also list **long-term equity anticipatory securities** (LEAPS), which are equity options with expiration dates longer than one year.

Over-the-counter (OTC) options on stocks for the retail trade all but disappeared with the growth of the organized exchanges in the 1970s. There is now, however, an active market in OTC options on currencies, swaps, and equities, primarily for institutional buyers. Like the forward market, the OTC options market is largely unregulated, consists of custom options, involves counterparty risk, and is facilitated by dealers in much the same way forwards markets are.

LOS 63.e: Identify the types of options in terms of the underlying instruments.

CFA® Program Curriculum, Volume 6, page 80

The three types of options we consider are (1) financial options, (2) options on futures, and (3) commodity options.

Financial options include equity options and other options based on stock indices, Treasury bonds, interest rates, and currencies. The strike price for financial options can be in terms of yield-to-maturity on bonds, an index level, or an exchange rate for *foreign currency options*. LIBOR-based *interest rate options* have payoffs based on the difference between LIBOR at expiration and the strike rate in the option.

Bond options are most often based on Treasury bonds because of their active trading. There are relatively few listed options on bonds—most are over-the-counter options. Bond options can be deliverable or settle in cash. The mechanics of bond options are like those of equity options, but are based on bond prices and a specific face value of the bond. The buyer of a call option on a bond will gain if interest rates fall and bond prices rise. A put buyer will gain when rates rise and bond prices fall.

Index options settle in cash, nothing is delivered, and the payoff is made directly to the option holder's account. The payoff on an index call (long) is the amount (if any) by which the index level at expiration exceeds the index level specified in the option (the strike price), multiplied by the *contract multiplier*. An equal amount will be deducted from the account of the index call option writer.

Example: Index options

Assume that you own a call option on the S&P 500 Index with an exercise price equal to 950. The multiplier for this contract is 250. Compute the payoff on this option assuming that the index is 962 at expiration.

Answer:

This is a call, so the expiration date payoff is (962 – 950) × $250 = $3,000.

Options on futures, sometimes called futures options, give the holder the right to buy or sell a specified futures contract on or before a given date at a given futures price, the strike price.

- *Call options* on futures contracts give the holder the right to enter into the long side of a futures contract at a given futures price. Assume that you hold a call option on a bond future at 98 (percent of face) and at expiration the futures price on the bond contract is 99. By exercising the call, you take on a long position in the futures contract, and the account is immediately marked to market based on the settlement price. Your account would be credited with cash in an amount equal to 1% (99 – 98) of the face value of the bonds covered by the contract. The seller of the exercised call will take on the short position in the futures contract, and the mark-to-market value of this position will generate the cash deposited to your account.
- *Put options* on futures contracts give the holder the option to take on a short futures position at a futures price equal to the strike price. The writer has the obligation to take on the opposite (long) position if the option is exercised.

Commodity options give the holder the right to either buy or sell a fixed quantity of some physical asset at a fixed (strike) price.

Some capital investment projects have provisions that give the company flexibility to adjust the project's cash flows while it is in progress (for example, an option to abandon the project before completion). Such **real options** have value that should be considered when evaluating a project's NPV.

Professor's Note: Evaluating projects with real options is covered in the Study Session on corporate finance at Level II.

LOS 63.f: Compare interest rate options with forward rate agreements (FRAs).

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Interest rate options are similar to the stock options except that the exercise price is an interest rate and the underlying asset is a reference rate such as LIBOR. Interest rate options are also similar to FRAs because there is no deliverable asset. Instead they are settled in cash, in an amount that is based on a notional amount and the spread between the strike rate and the reference rate. Most interest rate options are European options.

To see how interest rate options work, consider a long position in a 1-year LIBOR-based interest rate call option with a notional amount of $1,000,000 and a strike rate of 5%. For our example, let's assume that this option is costless for simplicity. If at expiration, LIBOR is greater than 5%, the option can be exercised and the owner will receive $1,000,000 × (LIBOR – 5%). If LIBOR is less than 5%, the option expires worthless and the owner receives nothing.

Now, let's consider a short position in a LIBOR-based interest rate put option with the same features as the call that we just discussed. Again, the option is assumed to be costless, with a strike rate of 5% and notional amount of $1,000,000. If at expiration, LIBOR falls below 5%, the option writer (short) must pay the put holder an amount equal to $1,000,000 × (5% – LIBOR). If at expiration, LIBOR is greater than 5%, the option expires worthless and the put writer makes no payments. If the rate is for less than one year, the payoff is adjusted. For example, if the reference rate for the option is 60-day LIBOR, the payoff would be $1,000,000 × (5% – LIBOR)(60/360) because the actual LIBOR rate and the strike rate are annualized rates.

Notice the one-sided payoff on these interest rate options. The long call receives a payoff when LIBOR exceeds the strike rate and receives nothing if LIBOR is below the strike rate. On the other hand, the short put position makes payments if LIBOR is below the strike rate, and makes no payments when LIBOR exceeds the strike rate.

The combination of the long interest rate call option plus a short interest rate put option has the same payoff as a forward rate agreement (FRA). To see this, consider the fixed-rate payer in a 5% fixed-rate, $1,000,000 notional, LIBOR-based FRA. Like our long call position, the fixed-rate payer will receive $1,000,000 × (LIBOR – 5%). And, like our short put position, the fixed-rate payer will pay $1,000,000 × (5% – LIBOR).

Professor's Note: For the exam, you need to know that a long interest rate call combined with a short interest rate put can have the same payoff as a long position in an FRA.

LOS 63.g: Define interest rate caps, floors, and collars.

CFA® Program Curriculum, Volume 6, page 83

An **interest rate cap** is a series of interest rate call options, having expiration dates that correspond to the reset dates on a floating-rate loan. Caps are often used to protect a floating-rate borrower from an increase in interest rates. Caps place a maximum (upper limit) on the interest payments on a floating-rate loan.

Caps pay when rates rise above the cap rate. In this regard, a cap can be viewed as a series of interest rate call options with strike rates equal to the cap rate. Each option in a cap is called a *caplet*.

An **interest rate floor** is a series of interest rate put options, having expiration dates that correspond to the reset dates on a floating-rate loan. Floors are often used to protect a floating-rate lender from a decline in interest rates. Floors place a minimum (lower limit) on the interest payments that are received from a floating-rate loan.

An interest rate floor on a loan operates just the opposite of a cap. The floor rate is a minimum rate on the payments on a floating-rate loan.

Floors pay when rates fall below the floor rate. In this regard, a floor can be viewed as a series of interest rate put options with strike rates equal to the floor rate. Each option in a floor is called a *floorlet*.

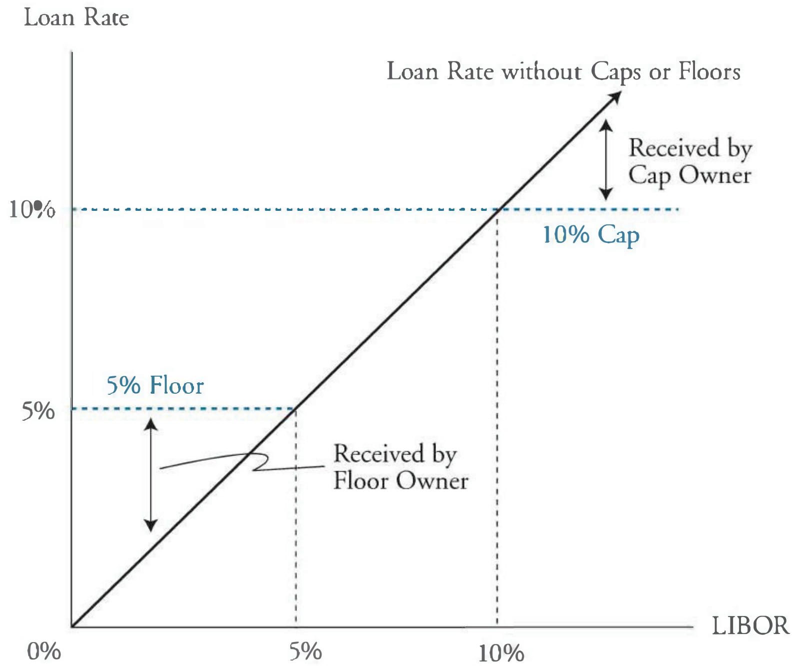
An **interest rate collar** combines a cap and a floor. A borrower with a floating-rate loan may *buy* a cap for protection against rates above the cap and *sell* a floor in order to defray some of the cost of the cap.

Let's review the information in Figure 1, which illustrates the payments from a cap and a floor. On each reset date of a floating-rate loan, the interest for the next period (e.g., 90 days) is determined on the basis of some reference rate. Here, we assume that LIBOR is the reference rate and that we have quarterly payment dates on the loan.

The figure shows the effect of a cap that is set at 10%. In the event that LIBOR rises above 10%, the cap will make a payment to the cap buyer to offset any interest expense in excess of an annual rate of 10%. A cap may be structured to cover a certain number of periods or for the entire life of a loan. The cap will make a payment at any future interest payment due date whenever the reference rate (LIBOR in our example) exceeds the cap rate. As indicated in the figure, the cap's payment is based on the difference between the reference rate and the cap rate. The amount of the payment will equal the notional amount specified in the cap contract times the difference between the cap rate and the reference rate. When used to hedge a loan, the notional amount is usually equal to the loan amount.

Figure 1 also illustrates a floor of 5% for our LIBOR-based loan. For any payment where the reference rate on the loan falls below 5%, there is an additional payment required by the floor to bring the total payment to 5% (1.25% quarterly on a 90-day LIBOR-based loan). Note that the issuer of a floating-rate note with both a cap and a floor (a collar) is long a cap and *short* (has sold) a floor. The note issuer receives a payment when rates are above the cap, and makes an additional payment when rates are below the floor (compared to just paying the reference rate).

Figure 1: Interest Rate Caps and Floors



LOS 63.h: Calculate and interpret option payoffs and explain how interest rate options differ from other types of options.

CFA® Program Curriculum, Volume 6, page 83

Calculating the payoff for a stock option, or other type of option with a monetary-based exercise price, is straightforward. At expiration, a call owner receives any amount by which the asset price exceeds the strike price, and zero otherwise. The holder of a put will receive any amount that the asset price is below the strike price at expiration, and zero otherwise.

While bonds are quoted in terms of yield-to-maturity, T-bills in discount yield, indices in index points, and currencies as an exchange rate, the same principle applies. That is, in each case, to get the payoff per unit of the relevant asset, we need to translate the asset value to a dollar value and the strike price (or rate, or yield) to a dollar strike price. We can then multiply this payoff times however many units of the asset are covered by the options contract.

- For a stock index option, we saw that these dollar values were obtained from multiplying the index level and the strike level by the multiplier specified in the contract. The resulting dollar payoffs are per contract.
- The payoff on options on futures is the cash the option holder receives when he exercises the option and the resulting futures position is marked to market.

The **payoffs on interest rate options** are different. For example, a call option based on 90-day LIBOR makes a payment based on a stated notional amount and the difference between 90-day LIBOR and the option's strike rate, times 90 / 360 to adjust for the interest rate period. The payment is made, not at option expiration, but at a future date corresponding to the term of the reference rate. For example, an option based on 90-day LIBOR will make a payment 90 days after the expiration date of the option. This payment date often corresponds to the date on which a LIBOR-based borrower would make the next interest payment on a loan.

Example: Computing the payoff for an interest rate option

Assume you bought a 60-day call option on 90-day LIBOR with a notional principal of \$1 million and a strike rate of 5%. Compute the payment that you will receive if 90-day LIBOR is 6% at contract expiration, and determine when the payment will be received.

Answer:

The interest savings on a \$1 million 90-day loan at 5% versus 6% is:

$$1 \text{ million} \times (0.06 - 0.05)(90 / 360) = \$2{,}500$$

This is the amount that will be paid by the call writer 90 days after expiration.

LOS 63.i: Define intrinsic value and time value, and explain their relationship.

CFA® Program Curriculum, Volume 6, page 88

An option's **intrinsic value** is the amount by which the option is in-the-money. It is the amount that the option owner would receive if the option were exercised. An option has zero intrinsic value if it is at the money or out of the money, regardless of whether it is a call or a put option.

Let's look at the value of a call option *at expiration.* If the expiration date price of the stock exceeds the strike price of the option, the call owner will exercise the option and receive S – X. If the price of the stock is less than or equal to the strike price, the call holder will let the option expire and get nothing.

The *intrinsic value of a call* option is the greater of (S – X) or 0. That is:

$$C = \max[0, S - X]$$

Similarly, the *intrinsic value of a put* option is (X – S) or 0, whichever is greater. That is:

$$P = \max[0, X - S]$$

Example: Intrinsic value

Consider a call option with a strike price of $50. Compute the intrinsic value of this option for stock prices of $55, $50, and $45.

Answer:

stock price = \$55: C = max[0, S – X] = max[0, (55 – 50)] = \$5

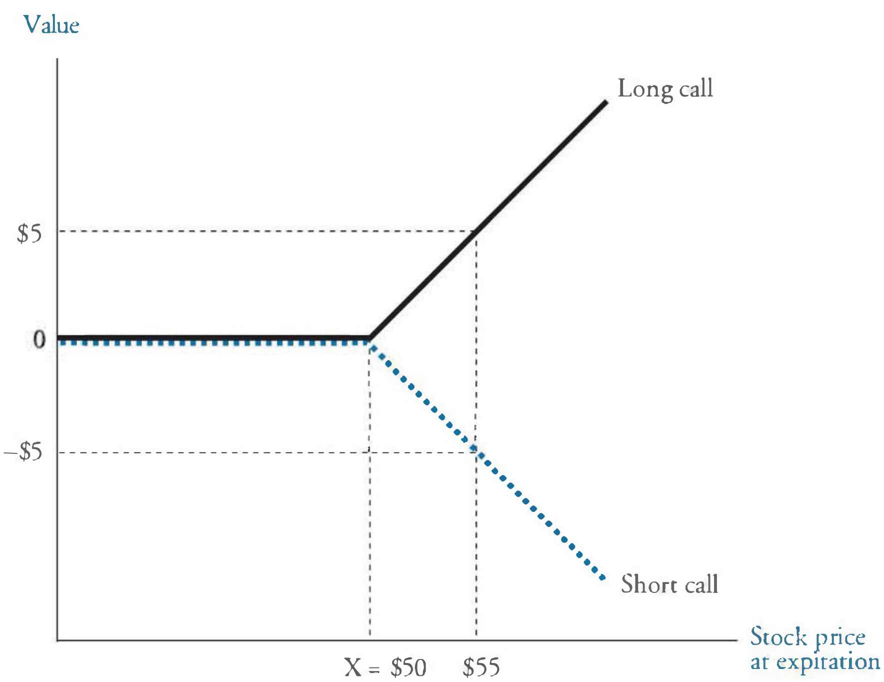
stock price = \$50: C = max[0, S – X] = max[0, (50 – 50)] = \$0

stock price = \$45: C = max[0, S – X] = max[0, (45 – 50)] = \$0

Notice that at expiration, if the stock is worth $50 or below, the call option is worth $0. Why? Because a rational option holder will not exercise the call option and take the loss. This one-sided feature of call options is illustrated in the option payoff diagram presented in Figure 2 for the call option we have used in this example.

Professor's Note: Option payoff diagrams are commonly used tools to illustrate the value of an option at expiration.

Figure 2: Call Option Payoff Diagram



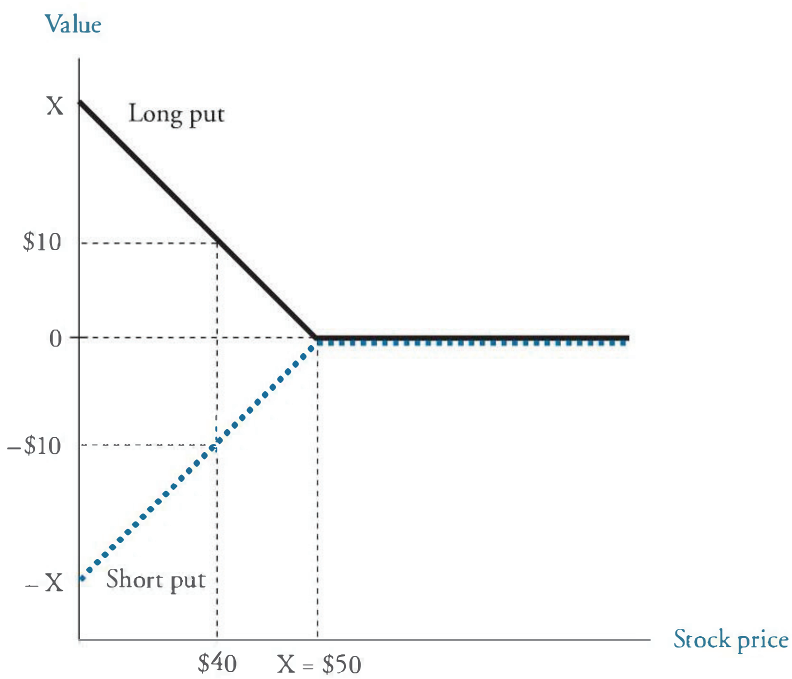
As indicated in Figure 2, the expiration date payoff to the owner is either zero or the amount that the option is in the money. For a call option writer (seller), the payoff is either zero or minus the amount it is in the money. There are no positive payoffs for an option writer. The option writer receives the premium and takes on the obligation to pay whatever the call owner gains.

With reference to Figure 2, you should make the following observations:

- The payoff to a long call position (the solid line) is a flat line which angles upward to the right at a 45 degree angle from the strike price, *X*.
- The payoff to the writer of a call (dotted line), is a flat line which angles downward to the right at a 45 degree angle from the strike price, *X*.
- Options are a zero-sum game. If you add the long call option's payoff to the short option's payoff, you will get a net payoff of zero.
- At a stock price of $55, the payoff to the long is $5, which is a $5 loss to the short.

Similar to our payoff diagram for a call option, Figure 3 illustrates the at-expiration payoff values for a put option. As indicated here, if the price of the stock is less than the strike price, the put owner will exercise the option and receive (X – S). If the price of the stock is greater than or equal to the strike price, the put holder will let the put option expire and get nothing (0). At a stock price of $40, the payoff on a long put is $10; the seller of the put (the short) would have a negative payoff because he must buy the stock at $50 and receive stock worth $40.

Figure 3: Put Option Payoff Diagram



The **time value** of an option is the amount by which the option premium exceeds the intrinsic value and is sometimes called the speculative value of the option. This relationship can be written as:

option value = intrinsic value + time value

As we discussed earlier, the intrinsic value of an option is the amount by which the option is in the money. At any point during the life of an options contract, its value will typically be greater than its intrinsic value. This is because there is some probability that the stock price will change in an amount that gives the option a positive payoff at expiration greater than the (current) intrinsic value. Recall that an option's intrinsic value (to a buyer) is the amount of the payoff at expiration and is bounded by zero. When an option reaches expiration there is no time remaining and the time value is zero. For American options and in most cases for European options, the longer the time to expiration, the greater the time value and, other things equal, the greater the option's premium (price).

LOS 63.j: Determine the minimum and maximum values of European options and American options.

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The following is some option terminology that we will use when addressing these LOS:

S_t = the price of the underlying stock at time t
X = the exercise price of the option
T = the time to expiration
c_t = the price of a European call at any time t prior to expiration at time = T
C_t = the price of an American call at any time t prior to expiration at time = T
p_t = the price of a European put at any time t prior to expiration at time = T
P_t = the price of an American put at any time t prior to expiration at time = T
RFR = the risk-free rate

Professor's Note: Please notice that lowercase letters are used to represent European-style options.

Lower bound. Theoretically, no option will sell for less than its intrinsic value and no option can take on a negative value. This means that the lower bound for any option is zero. *The lower bound of zero applies to both American and European options.*

Upper bound for call options. The maximum value of either an American or a European *call* option at any time t is the time-t share price of the underlying stock. This makes sense because no one would pay a price for the right to buy an asset that exceeded the asset's value. It would be cheaper to simply buy the underlying asset. At time t = 0, the upper boundary condition can be expressed respectively for American and European call options as:

$$C_0 \leq S_0 \text{ and } c_0 \leq S_0$$

Upper bound for put options. The price for an American put option cannot be more than its strike price. This is the exercise value in the event the underlying stock price goes to zero. However, since European puts cannot be exercised prior to expiration, the maximum value is the present value of the exercise price discounted at the risk-free rate. Even if the stock price goes to zero, and is expected to stay at zero, the intrinsic value,

X, will not be received until the expiration date. At time t = 0, the upper boundary condition can be expressed for American and European put options, respectively, as:

$$P_0 \leq X \text{ and } p_0 \leq \frac{X}{(1+\text{RFR})^T}$$

The minimum and maximum boundary conditions for the various types of options at any time t are summarized in Figure 4.

Figure 4: Option Value Limits

Option	*Minimum Value*	*Maximum Value*
European call	$c_t \geq 0$	$c_t \leq S_t$
American call	$C_t \geq 0$	$C_t \leq S_t$
European put	$p_t \geq 0$	$p_t \leq X/(1 + \text{RFR})^{(T-t)}$
American put	$P_t \geq 0$	$P_t \leq X$

Professor's Note: The values in the table are the theoretical limits on the value of options. In the next section, we will establish more restrictive limits for option prices.

LOS 63.k: Calculate and interpret the lowest prices of European and American calls and puts based on the rules for minimum values and lower bounds.

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Professor's Note: The option boundary conditions that we discuss below will be important when you study option pricing models. For now, if you follow the logic leading up to the results presented in Figure 5, you will be prepared to deal with these LOS. Knowing and understanding the results in Figure 5 satisfy the requirements of these LOS; the following derivation of those results need not be memorized.

At this point, we know that for American-style options, which can be immediately exercised, the minimum price has to be the option's intrinsic value. For at-the-money and out-of-the money options, this minimum is zero, because options cannot have negative values. For in-the-money American options, the minima are simply the intrinsic values S – X for calls, and X – S for puts. If this were not the case, you could buy the option for less than its intrinsic value and immediately exercise it for a guaranteed profit. So, for American options, we can express the *lower bound on the option price* at any time t prior to expiration as:

$$C_t = \max[0, S_t - X]$$
$$P_t = \max[0, X - S_t]$$

For European options, however, the minima are not so obvious because these options are not exercisable immediately. To determine the lower bounds for European options, we can examine the value of a portfolio in which the option is combined with a long or short position in the stock and a pure discount bond.

For a *European call option,* construct the following portfolio:

- A long at-the-money European call option with exercise price *X*, expiring at time t = T.
- A long discount bond priced to yield the risk-free rate that pays *X* at option expiration.
- A short position in one share of the underlying stock priced at $S_0 = X$.

The current value of this portfolio is $c_0 - S_0 + X / (1 + RFR)^T$.

At expiration time, t = T, this portfolio will pay $c_T - S_T + X$. That is, we will collect $c_T = \max[0, S_T - X]$ on the call option, pay S_T to cover our short stock position, and collect X from the maturing bond.

- If $S_T \geq X$, the call is in-the-money, and the portfolio will have a zero payoff because the call pays $S_T - X$, the bond pays $+X$, and we pay $-S_T$ to cover our short position. That is, the time t = T payoff is: $S_T - X + X - S_T = 0$.
- If $X > S_T$ the call is out-of-the-money, and the portfolio has a positive payoff equal to $X - S_T$ because the call value, c_T, is zero, we collect *X* on the bond, and pay $-S_T$ to cover the short position. So, the time t = T payoff is: $0 + X - S_T = X - S_T$.

Note that no matter whether the option expires in-the-money, at-the-money, or out-of-the-money, the portfolio value will be equal to or greater than zero. We will never have to make a payment.

To prevent arbitrage, any portfolio that has no possibility of a negative payoff cannot have a negative value. Thus, we can state the value of the portfolio *at time t = 0* as:

$$c_0 - S_0 + X / (1 + RFR)^T \geq 0$$

which allows us to conclude that:

$$c_0 \geq S_0 - X / (1 + RFR)^T$$

Combining this result with the earlier minimum on the call value of zero, we can write:

$$c_0 \geq \max[0, S_0 - X / (1 + RFR)^T]$$

Note that $X / (1 + RFR)^T$ is the present value of a pure discount bond with a face value of *X*.

Based on these results, we can now state the **lower bound for the price of an American call** as:

$$C_0 \geq \max[0, S_0 - X / (1 + RFR)^T]$$

How can we say this? This conclusion follows from the following two facts:

1. The early exercise feature on an American call makes it worth at least as much as an equivalent European call (i.e., $C_t \geq c_t$).
2. The lower bound for the value of a European call is equal to or greater than the theoretical lower bound for an American call. For example, $\max[0, S_0 - X / (1 + RFR)^T] \geq \max[0, S_0 - X]$.

Professor's Note: Don't get bogged down here. We just use the fact that an American call is worth at least as much as a European call to claim that the lower bound on an American call is at least as much as the lower bound on a European call.

Derive the **minimum value of a European put option** by forming the following portfolio at time t = 0:

- A long at-the-money European put option with exercise price X, expiring at t = T.
- A short position on a risk-free bond priced at $X / (1 + RFR)^T$. This is the same as borrowing an amount equal to $X / (1 + RFR)^T$.
- A long position in a share of the underlying stock priced at S_0.

At expiration time t = T, this portfolio will pay $p_T + S_T - X$. That is, we will collect $p_T = \max[0, X - S_T]$ on the put option, receive S_T from the stock, and pay $-X$ on the bond issue (loan).

- If $S_T > X$, the payoff will equal: $p_T + S_T - X = S_T - X$.
- If $S_T \leq X$, the payoff will be zero.

Again, a no-arbitrage argument can be made that the portfolio value must be zero or greater, because there are no negative payoffs to the portfolio.

At time t = 0, this condition can be written as:

$$p_0 + S_0 - X / (1 + RFR)^T \geq 0$$

and rearranged to state the minimum value for a European put option at time t = 0 as:

$$p_0 \geq X / (1 + RFR)^T - S_0$$

We have now established the **minimum bound on the price of a European put option** as:

$$p_0 \geq \max[0, X / (1 + RFR)^T - S_0]$$

Professor's Note: Notice that the lower bound on a European put is below that of an American put option (i.e., $\max[0, X - S_0]$). This is because when it's in the money, the American put option can be exercised immediately for a payoff of $X - S_0$.

Figure 5 summarizes what we now know regarding the boundary prices for American and European options at any time *t* prior to expiration at time t = T.

Figure 5: Lower and Upper Bounds for Options

Option	*Minimum Value*	*Maximum Value*
European call	$c_t \geq \max[0, S_t - X / (1 + RFR)^{T-t}]$	S_t
American call	$C_t \geq \max[0, S_t - X / (1 + RFR)^{T-t}]$	S_t
European put	$p_t \geq \max[0, X / (1 + RFR)^{T-t} - S_t]$	$X / (1 + RFR)^{T-t}$
American put	$P_t \geq \max[0, X - S_t]$	X

Professor's Note: For the exam, know the price limits in Figure 5. You will not be asked to derive them, but you may be expected to use them.

Example: Minimum prices for American vs. European puts

Compute the lowest possible price for 4-month American and European 65 puts on a stock that is trading at 63 when the risk-free rate is 5%.

Answer:

American put: $P_0 \geq \max[0, X - S_0] = \max[0,2] = \$2$

European put: $p_0 \geq \max[0, X / (1 + RFR)^T - S_0] = \max[0, 65 / 1.05^{0.333} - 63] = \$0.95$

Example: Minimum prices for American vs. European calls

Compute the lowest possible price for 3-month American and European 65 calls on a stock that is trading at 68 when the risk-free rate is 5%.

Answer:

$C_0 \geq \max[0, S_0 - X / (1 + RFR)^T] = \max[0, 68 - 65 / 1.05^{0.25}] = \$3.79$

$c_0 \geq \max[0, S_0 - X / (1 + RFR)^T] = \max[0, 68 - 65 / 1.05^{0.25}] = \$3.79$

LOS 63.l: Explain how option prices are affected by the exercise price and the time to expiration.

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The result we are after here is a simple and somewhat intuitive one. That is, given two puts that are identical in all respects except exercise price, the one with the higher exercise price will have at least as much value as the one with the lower exercise price. This is because the underlying stock can be sold at a higher price. Similarly, given two calls that are identical in every respect except exercise price, the one with the lower exercise price will have at least as much value as the one with the higher exercise price. This is because the underlying stock can be purchased at a lower price.

Professor's Note: The derivation of this result is included here although it is not explicitly required by the LOS.

The method here, for both puts and calls, is to combine two options with different exercise prices into a portfolio and examine the portfolio payoffs at expiration for the three possible stock price ranges. We use the fact that a portfolio with no possibility of a negative payoff cannot have a negative value to establish the pricing relations for options with differing times to expiration.

For $X_1 < X_2$, consider a portfolio at time *t* that holds the following positions:

$c_t(X_1)$ = a long call with an exercise price of X_1

$c_t(X_2)$ = a short call with an exercise price of X_2

The three expiration date (t = T) conditions and payoffs that need to be considered here are summarized in Figure 6.

Figure 6: Exercise Price vs. Call Price

Expiration Date Condition	*Option Value*	*Portfolio Payoff*
$S_T \leq X_1$	$c_T(X_1) = c_T(X_2) = 0$	0
$X_1 < S_T < X_2$	$c_T(X_1) = S_T - X_1$ $c_T(X_2) = 0$	$S_T - X_1 > 0$
$X_2 \leq S_T$	$c_T(X_1) = S_T - X_1$ $c_T(X_2) = S_T - X_2$	$(S_T - X_1) - (S_T - X_2)$ $= X_2 - X_1 > 0$

With no negative payoffs at expiration, the current portfolio of $c_0(X_1) - c_0(X_2)$ must have a value greater than or equal to zero, and we have proven that $c_0(X_1) \geq c_0(X_2)$.

Similarly, consider a portfolio short a put with exercise price X_1 and long a put with exercise price X_2, where $X_1 < X_2$. The expiration date payoffs that we need to consider are summarized in Figure 7.

Figure 7: Exercise Price vs. Put Price

Expiration Date Condition	*Option Value*	*Portfolio Payoff*
$S_T \geq X_2$	$p_T(X_1) = p_T(X_2) = 0$	0
$X_2 > S_T > X_1$	$p_T(X_1) = 0$ $p_T(X_2) = X_2 - S_T$	$X_2 - S_T > 0$
$X_1 \geq S_T$	$p_T(X_1) = X_1 - S_T$ $p_T(X_2) = X_2 - S_T$	$(X_2 - S_T) - (X_1 - S_T)$ $= X_2 - X_1 > 0$

Here again, with no negative payoffs at expiration, the current portfolio of $p_0(X_2) - p_0(X_1)$ must have a value greater than or equal to zero, which proves that $p_0(X_2) \geq p_0(X_1)$.

In summary, we have shown that, all else being equal:

- Call prices are inversely related to exercise prices.
- Put prices are directly related to exercise price.

In general, a **longer time to expiration** will increase an option's value. For far out-of-the-money options, the extra time may have no effect, but we can say the longer-term option will be no less valuable that the shorter-term option.

The case that doesn't fit this pattern is the European put. Recall that the minimum value of an in-the-money European put at any time *t* prior to expiration is $X / (1 + RFR)^{T-t} - S_t$. While longer time to expiration increases option value through increased volatility, it decreases the present value of any option payoff at expiration. For this reason, we cannot state positively that the value of a longer European put will be greater than the value of a shorter-term put.

If volatility is high and the discount rate low, the extra time value will be the dominant factor and the longer-term put will be more valuable. Low volatility and high interest rates have the opposite effect and the value of a longer-term in-the-money put option can be less than the value of a shorter-term put option.

LOS 63.m: Explain put–call parity for European options, and explain how put–call parity is related to arbitrage and the construction of synthetic options.

CFA® Program Curriculum, Volume 6, page 98

Our derivation of put-**call parity** is based on the payoffs of two portfolio combinations, a fiduciary call and a protective put.

A *fiduciary call* is a combination of a pure-discount, riskless bond that pays *X* at maturity and a call with exercise price *X*. The payoff for a fiduciary call at expiration is *X* when the call is out of the money, and $X + (S - X) = S$ when the call is in the money.

A *protective put* is a share of stock together with a put option on the stock. The expiration date payoff for a protective put is $(X - S) + S = X$ when the put is in the money, and *S* when the put is out of the money.

Professor's Note: When working with put-call parity, it is important to note that the exercise prices on the put and the call and the face value of the riskless bond are all equal to X.

When the put is in the money, the call is out of the money, and both portfolios pay *X* at expiration.

Similarly, when the put is out of the money and the call is in the money, both portfolios pay *S* at expiration.

Put-call parity holds that portfolios with identical payoffs must sell for the same price to prevent arbitrage. We can express the put-call parity relationship as:

$$c + X / (1 + RFR)^T = S + p$$

Equivalencies for each of the individual securities in the put-call parity relationship can be expressed as:

$$S = c - p + X / (1 + RFR)^T$$
$$p = c - S + X / (1 + RFR)^T$$
$$c = S + p - X / (1 + RFR)^T$$
$$X / (1 + RFR)^T = S + p - c$$

The single securities on the left-hand side of the equations all have exactly the same payoffs as the portfolios on the right-hand side. The portfolios on the right-hand side are the synthetic equivalents of the securities on the left. Note that the options must be European-style and the puts and calls must have the same exercise price for these relations to hold.

For example, to synthetically produce the payoff for a long position in a share of stock, use the following relationship:

$$S = c - p + X / (1 + RFR)^T$$

This means that the payoff on a long stock can be synthetically created with a long call, a short put, and a long position in a risk-free discount bond.

The other securities in the put-call parity relationship can be constructed in a similar manner.

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Professor's Note: After expressing the put-call parity relationship in terms of the security you want to synthetically create, the sign on the individual securities will indicate whether you need a long position (+ sign) or a short position (– sign) in the respective securities.

Example: Call option valuation using put-call parity

Suppose that the current stock price is \$52 and the risk-free rate is 5%. You have found a quote for a 3-month put option with an exercise price of \$50. The put price is \$1.50, but due to light trading in the call options, there was not a listed quote for the 3-month, \$50 call. Estimate the price of the 3-month call option.

Answer:

Rearranging put-call parity, we find that the call price is:

$$\text{call} = \text{put} + \text{stock} - \text{present value}(X)$$

$$\text{call} = \$1.50 + \$52 - \frac{\$50}{1.05^{0.25}} = \$4.11$$

This means that if a 3-month, \$50 call is available, it should be priced at \$4.11 per share.

LOS 63.n: Explain how cash flows on the underlying asset affect put–call parity and the lower bounds of option prices.

CFA® Program Curriculum, Volume 6, page 104

If the asset has positive cash flows over the period of the option, the cost of the asset is less by the present value of the cash flows. You can think of buying a stock for S and simultaneously borrowing the present value of the cash flows, PV_{CF}. The cash flow(s) will provide the payoff of the loan(s), and the loan(s) will reduce the net cost of the asset to $S - PV_{CF}$. Therefore, for assets with positive cash flows over the term of the option, we can substitute this (lower) net cost, $S - PV_{CF}$, for S in the lower bound conditions and in all the parity relations.

The lower bounds for European options at time t = 0 can be expressed as:

$c_0 \geq \max[0, S_0 - PV_{CF} - X / (1 + RFR)^T]$, and
$p_0 \geq \max[0, X / (1 + RFR)^T - (S_0 - PV_{CF})]$

The put-call parity relations can be adjusted to account for asset cash flows in the same manner.

$(S_0 - PV_{CF}) = C - P + X / (1 + RFR)^T$, and
$C + X / (1 + RFR)^T = (S_0 - PV_{CF}) + P$

LOS 63.o: Determine the directional effect of an interest rate change or volatility change on an option's price.

CFA® Program Curriculum, Volume 6, page 105

When interest rates increase, the value of a call option increases and the value of a put option decreases (holding the price of the underlying security constant). This general result may not apply to interest rate options or to bond or T-bill options, where a change in the risk-free rate may affect the value of the underlying asset.

The no-arbitrage relations for puts and calls make these statements obvious:

$$C = S + P - X / (1 + RFR)^T$$
$$P = C - S + X / (1 + RFR)^T$$

Here we can see that an increase in RFR decreases $X / (1 + RFR)^T$. This will have the effect of increasing the value of the call, and decreasing the value of the put. A decrease in interest rates will decrease the value of a call option and increase the value of a put option.

Professor's Note: Admittedly, this is a partial analysis of these equations, but it does give the right directions for the effects of interest rate changes and will help you remember them if this relation is tested on the exam.

Greater volatility in the value of an asset or interest rate underlying an option contract increases the values of both puts and calls (and caps and floors). The reason is that options are one-sided. Since an option's value falls no lower than zero when it expires out of the money, the increased upside potential (with no greater downside risk) from increased volatility, increases the option's value.

KEY CONCEPTS

LOS 63.a

A call option on a financial or physical asset gives the option's owner the right, but not the obligation, to buy a specified quantity of the asset from the option writer at the exercise price specified in the option for a given time period. The writer of a call option is obligated to sell the asset at the exercise price if the option's owner chooses to exercise it.

A put option on a financial or physical asset gives the option's owner the right, but not the obligation, to sell a specified quantity of the asset to the option writer at the exercise price specified in the option for a given time period. The writer of a put option is obligated to purchase the asset at the exercise price if the option's owner chooses to exercise it.

The owner (buyer) of an option is said to be long the option, and the writer (seller) of an option is said to be short the option.

LOS 63.b

American options can be exercised at any time up to the option's expiration date.

European options can be exercised only at the option's expiration date.

LOS 63.c

Moneyness for puts and calls is determined by the difference between the strike price (X) and the market price of the underlying stock (S):

Moneyness	*Call Option*	*Put Option*
In the money	$S > X$	$S < X$
At the money	$S = X$	$S = X$
Out of the money	$S < X$	$S > X$

LOS 63.d

Exchange-traded options are standardized, regulated, and backed by a clearinghouse. Over-the-counter options are largely unregulated custom options that have counterparty risk.

LOS 63.e

Options are available on financial securities, futures contracts, interest rates, and commodities.

LOS 63.f

Interest rate option payoffs are the difference between the market and strike rates, adjusted for the loan period, multiplied by the principal amount.

At expiration, an interest rate call receives a payment when the reference rate is above the strike rate, and an interest rate put receives a payment when the reference rate is below the strike rate.

An FRA can be replicated with two interest rate options: a long call and a short put.

LOS 63.g

Interest rate caps put a maximum (upper limit) on the payments on a floating-rate loan and are equivalent (from the borrower's perspective) to a series of long interest rate calls at the cap rate.

Interest rate floors put a minimum (lower limit) on the payments on a floating-rate loan and are equivalent (from the borrower's perspective) to a series of short interest rate puts at the floor rate.

An interest rate collar combines a cap and a floor. A borrower can create a collar on a floating-rate loan by buying a cap and selling a floor.

LOS 63.h

The payoff to the holder of a call or put option on a stock is the option's intrinsic value. Payment occurs at expiration of the option.

Payoffs on interest rate options are paid after expiration, at the end of the interest rate (loan) period specified in the contract.

LOS 63.i

The intrinsic value of an option is the payoff from immediate exercise if the option is in the money, and zero otherwise.

The time (speculative) value of an option is the difference between its premium (market price) and its intrinsic value. At expiration, time value is zero.

LOS 63.j,k

Minimum and maximum option values:

Option	*Minimum Value*	*Maximum Value*
European call	$c_t \geq \max[0, S_t - X / (1 + RFR)^{T-t}]$	S_t
American call	$C_t \geq \max[0, S_t - X / (1 + RFR)^{T-t}]$	S_t
European put	$p_t \geq \max[0, X / (1 + RFR)^{T-t} - S_t]$	$X / (1 + RFR)^{T-t}$
American put	$P_t \geq \max[0, X - S_t]$	X

LOS 63.l

Calls with lower exercise prices are worth at least as much as otherwise identical calls with higher exercise prices (and typically more).

Puts with higher exercise prices are worth at least as much as otherwise identical puts with lower exercise prices (and typically more).

Otherwise identical options are worth more when there is more time to expiration, with two exceptions:

- Far out-of-the-money options with different expiration dates may be equal in value.
- With European puts, longer time to expiration may decrease an option's value when they are deep in the money.

LOS 63.m

A fiduciary call (a call option and a risk-free zero-coupon bond that pays the strike price X at expiration) and a protective put (a share of stock and a put at X) have the same payoffs at expiration, so arbitrage will force these positions to have equal prices: $c + X / (1 + RFR)^T = S + p$. This establishes put-call parity for European options.

Based on the put-call parity relation, a synthetic security (stock, bond, call, or put) can be created by combining long and short positions in the other three securities.

- $c = S + p - X / (1 + RFR)^T$
- $p = c - S + X / (1 + RFR)^T$
- $S = c - p + X / (1 + RFR)^T$
- $X / (1 + RFR)^T = S + p - c$

LOS 63.n

When the underlying asset has positive cash flows, the minima, maxima, and put-call parity relations are adjusted by subtracting the present value of the expected cash flows from the assets over the life of the option. That is, S can be replaced by (S – PV of expected cash flows).

LOS 63.o

An increase in the risk-free rate will increase call values and decrease put values (for options that do not explicitly depend on interest rates or bond values).

Increased volatility of the underlying asset or interest rate increases both put values and call values.

Concept Checkers

1. Which of the following statements about moneyness is *least accurate*? When:
   A. S – X is > 0, a call option is in the money.
   B. S – X = 0, a call option is at the money.
   C. S > X, a put option is in the money.

2. Which of the following statements about American and European options is *most accurate*?
   A. There will always be some price difference between American and European options because of exchange-rate risk.
   B. European options allow for exercise on or before the option expiration date.
   C. Prior to expiration, an American option may have a higher value than an equivalent European option.

3. Which of the following statements about put and call options is *least accurate*?
   A. The price of the option is less volatile than the price of the underlying stock.
   B. Option prices are generally higher the longer the time until the option expires.
   C. For put options, the higher the strike price relative to the stock's underlying price, the more the put is worth.

4. Which of the following statements about options is *most accurate*?
   A. The writer of a put option has the obligation to sell the asset to the holder of the put option.
   B. The holder of a call option has the obligation to sell to the option writer if the stock's price rises above the strike price.
   C. The holder of a put option has the right to sell to the writer of the option.

5. A *decrease* in the risk-free rate of interest will:
   A. increase put and call prices.
   B. decrease put prices and increase call prices.
   C. increase put prices and decrease call prices.

6. A $40 call on a stock trading at $43 is priced at $5. The time value of the option is:
   A. $2.
   B. $5.
   C. $8.

7. Prior to expiration, an American put option on a stock:
   A. is bounded by $S - X / (1 + RFR)^T$.
   B. will never sell for less than its intrinsic value.
   C. can never sell for more than its intrinsic value.

8. The owner of a call option on oil futures with a strike price of $68.70:
   A. can exercise the option and take delivery of the oil.
   B. can exercise the option and take a long position in oil futures.
   C. would never exercise the option when the spot price of oil is less than the strike price.

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9. The lower bound for a European put option is:
   A. max(0, S – X).
   B. max[0, X / $(1 + RFR)^T$ – S].
   C. max[0, S – X / $(1 + RFR)^T$].

10. The lower bound for an American call option is:
   A. max(0, S – X).
   B. max[0, X /$(1 + RFR)^T$ – S].
   C. max[0, S – X / $(1 + RFR)^T$].

11. To account for positive cash flows from the underlying asset, we need to adjust the put-call parity formula by:
   A. adding the future value of the cash flows to *S*.
   B. adding the future value of the cash flows to *X*.
   C. subtracting the present value of the cash flows from *S*.

12. A forward rate agreement is equivalent to the following interest rate options:
   A. long a call and a put.
   B. short a call and long a put.
   C. long a call and short a put.

13. The payoff on an interest rate option:
   A. comes only at exercise.
   B. is greater the higher the "strike" rate.
   C. comes some period after option expiration.

14. An interest rate floor on a floating-rate note (from the issuer's perspective) is equivalent to a series of:
   A. long interest rate puts.
   B. short interest rate puts.
   C. short interest rate calls.

15. Which of the following relations is *least likely* accurate?
   A. $P = C - S + X / (1 + RFR)^T$.
   B. $C = S - P + X / (1 + RFR)^T$.
   C. $X / (1 + RFR)^T - P = S - C$.

16. A stock is selling at \$40, a 3-month put at \$50 is selling for \$11, a 3-month call at \$50 is selling for \$1, and the risk-free rate is 6%. How much, if anything, can be made on an arbitrage?
   A. \$0 (no arbitrage).
   B. \$0.28.
   C. \$0.72.

17. Which of the following will *increase* the value of a put option?
   A. An increase in volatility.
   B. A decrease in the exercise price.
   C. A decrease in time to expiration.

ANSWERS – CONCEPT CHECKERS

1. C A put option is out of the money when S > X and in the money when S < X. The other statements are true.

2. C American and European options both give the holder the right to exercise the option at expiration. An American option also gives the holder the right of early exercise, so American options will be worth more than European options when the right to early exercise is valuable, and they will have equal value when it is not, $C_t \geq c_t$ and $P_t \geq p_t$.

3. A Option prices are *more* volatile than the price of the underlying stock. The other statements are true. Options have time value, which means prices are higher the longer the time until the option expires, and a higher strike price increases the value of a put option.

4. C The holder of a put option has the right to sell to the writer of the option. The writer of the put option has the obligation to buy, and the holder of the call option has the right, but not the obligation to buy.

5. C Interest rates are inversely related to put prices and directly related to call prices.

6. A The intrinsic value is S – X = \$43 – \$40 = \$3. So, the time value is \$5 – \$3 = \$2.

7. B At any time *t*, an American put will never sell below intrinsic value, but may sell for more than that. The lower bound is $\max[0, X - S_t]$.

8. B A call on a futures contract gives the holder the right to buy (go long) a futures contract at the exercise price of the call. It is not the current spot price of the asset underlying the futures contract that determines whether a futures option is in the money, it is the futures contract price (which may be higher).

9. B The lower bound for a European put ranges from zero to the present value of the exercise price less the prevailing stock price, where the exercise price is discounted at the risk-free rate.

10. C The lower bound for an American call ranges from zero to the prevailing stock price less the present value of the exercise price discounted at the risk-free rate.

11. C If the underlying asset used to establish the put-call parity relationship generates a cash flow prior to expiration, the asset's value must be reduced by the present value of the cash flow discounted at the risk-free rate.

12. C The payoff to a FRA is equivalent to that of a long interest rate call option and a short interest rate put option.

13. C The payment on a long put increases as the strike rate increases, but not for calls. There is only one payment and it comes after option expiration by the term of the underlying rate.

14. B Short interest rate puts require a payment when the market rate at expiration is below the strike rate, just as lower rates can require a payment from a floor.

15. B The put-call parity relationship is $S + P = C + X / (1 + RFR)^T$. All individual securities can be expressed as rearrangements of this basic relationship.

16. C A synthetic stock is: $S = C - P + X / (1 + RFR)^T = \$1 - \$11 + 50 / (1.06)^{0.25} = \$39.28$. Since the stock is selling for \$40, you can short a share of stock for \$40 and buy the synthetic for an immediate arbitrage profit of \$0.72.

17. A Increased volatility of the underlying asset increases both put values and call values.

The following is a review of the Derivatives principles designed to address the learning outcome statements set forth by CFA Institute. This topic is also covered in:

Swap Markets and Contracts

Study Session 17

Exam Focus

This topic review introduces swaps. The first thing you must learn is the mechanics of swaps so that you can calculate the payments on any of the types of swaps covered. Beyond that, you should be able to recognize that the cash flows of a swap can be duplicated with capital markets transactions (make a loan, issue a bond) or with other derivatives (a series of forward rate agreements or interest rate options). Common mistakes include forgetting that the current-period floating rate determines the next payment, forgetting to adjust the interest rates for the payment period, forgetting to add any margin above the floating rate specified in the swap, and forgetting that currency swaps involve an exchange of currencies at the initiation and termination of the swap. Don't do these things.

Swap Characteristics

Before we get into the details of swaps, a simple introduction may help as you go through the different types of swaps. You can view interest rate swaps as the exchange of one loan for another. If you lend me \$10,000 at a floating rate, and I lend you \$10,000 at a fixed rate, we have created a swap. There is no reason for the \$10,000 to actually change hands. The two equal loans make this pointless. At each payment date, I will make a payment to you based on the floating rate, and you will make one to me based on the fixed rate. Again, it makes no sense to exchange the full amounts; the one with the larger payment liability will make a payment of the difference to the other. This describes the payments of a fixed-for-floating or "plain vanilla" swap.

A currency swap can be viewed the same way. If I lend you 1,000,000 euros at the euro rate of interest, and you lend me the equivalent amount of yen at today's exchange rate at the yen rate of interest, we have done a currency swap. We will "swap" back these same amounts of currency at the maturity date of the two loans. In the interim, I borrowed yen, so I make yen interest payments, and you borrowed euros and must make interest payments in euros.

For other types of swaps, we just need to describe how the payments are calculated on the loans. For an equity swap, I could promise to make quarterly payments on your loan to me equal to the return on a stock index, and you could promise to make fixed-rate (or floating-rate) payments to me. If the stock index goes down, my payments to you are negative (i.e., you make a fixed-rate payment to me *and* a payment equal to the decline in the index over the quarter). If the index went up over the quarter, I would make a payment based on the percentage increase in the index. Again, the payments could be "netted" so that only the difference changes hands.

This intuitive explanation of swaps should make the following a bit easier to understand. Now let's dive into the mechanics and terminology of swaps. We have to specify exactly how the interest payments will be calculated, how often they are made, how much is to be loaned, and how long the loans are for. Swaps are custom instruments, and we can specify any terms both of us can agree on.

LOS 64.a: Describe the characteristics of swap contracts and explain how swaps are terminated.

CFA® Program Curriculum, Volume 6, page 120

Swaps are agreements to exchange a series of cash flows on periodic *settlement dates* over a certain time period (e.g., quarterly payments over two years). In the simplest type of swap, one party makes *fixed-rate* interest payments on the notional principal specified in the swap in return for *floating-rate* payments from the other party. At each settlement date, the two payments are *netted* so that only one (net) payment is made. The party with the greater liability makes a payment to the other party. The length of the swap is termed the *tenor* of the swap and the contract ends on the termination date. A swap can be decomposed into a series of forward contracts (FRAs) that expire on the settlement dates.

In many respects, swaps are similar to forwards:

- Swaps typically require no payment by either party at initiation.
- Swaps are custom instruments.
- Swaps are not traded in any organized secondary market.
- Swaps are largely unregulated.
- Default risk is an important aspect of the contracts.
- Most participants in the swaps market are large institutions.
- Individuals are rarely swaps market participants.

There are swaps facilitators who bring together parties with needs for the opposite sides of swaps. There are also dealers, large banks and brokerage firms, who act as principals in trades just as they do in forward contracts. It is a large business; the total notional principal of swaps contracts is estimated at over $50 trillion.

How Swaps are Terminated

There are **four** ways **to terminate a swap** prior to its original termination date.

1. *Mutual termination.* A cash payment can be made by one party that is acceptable to the other party. Like forwards, swaps can accumulate value as market prices or interest rates change. If the party that has been disadvantaged by the market movements is willing to make a payment of the swap's value to the counterparty, and the counterparty is willing to accept it, they can mutually terminate the swap.

2. *Offsetting contract.* Just as with forwards, if the terms of the original counterparty offers for early termination are unacceptable, the alternative is to enter an offsetting swap. If our 5-year quarterly-pay floating swap has two years to go, we can seek a current price on a pay-fixed (receive floating) swap that will provide our floating payments and leave us with a fixed-rate liability.

Just as with forwards, exiting a swap may involve taking a loss. Consider the case where we receive 3% fixed on our original 5-year pay floating swap, but must pay 4% fixed on the offsetting swap. We have locked in a loss because we must pay 1% higher rates on the offsetting swap than we receive on the swap we are offsetting. We must make quarterly payments for the next two years, and receive nothing in return. Exiting a swap through an offsetting swap with other than the original counterparty will also expose the investor to default risk, just as with forwards.

3. *Resale.* It is possible to sell the swap to another party, with the permission of the counterparty to the swap. This would be unusual, however, as there is not a functioning secondary market.
4. *Swaption.* A **swaption** is an option to enter into a swap. The option to enter into an offsetting swap provides an option to terminate an existing swap. Consider that, in the case of the previous 5-year pay floating swap, we purchased a 3-year call option on a 2-year pay fixed swap at 3%. Exercising this swap would give us the offsetting swap to exit our original swap. The cost for such protection is the swaption premium.

LOS 64.b: Describe, calculate, and interpret the payments of currency swaps, plain vanilla interest rate swaps, and equity swaps.

CFA® Program Curriculum, Volume 6, page 123

In a **currency swap**, one party makes payments denominated in one currency, while the payments from the other party are made in a second currency. Typically, the notional amounts of the contract, expressed in both currencies at the current exchange rate, are exchanged at contract initiation and returned at the contract termination date in the same amounts.

An example of a currency swap is as follows: Party 1 pays Party 2 $10 million at contract initiation in return for €9.8 million. On each of the settlement dates, Party 1, having received euros, makes payments at a 6% annualized rate in euros on the €9.8 million to Party 2. Party 2 makes payments at an annualized rate of 5% on the $10 million to Party 1. These settlement payments are both made. They are not netted as they are in a single currency interest rate swap.

As an example of what motivates a currency swap, consider that a U.S. firm, Party A, wishes to establish operations in Australia and wants to finance the costs in Australian dollars (AUD). The firm finds, however, that issuing debt in AUD is relatively more expensive than issuing USD-denominated debt, because they are relatively unknown in Australian financial markets. An alternative to issuing AUD-denominated debt is to issue USD debt and enter into a USD/AUD currency swap. Through a swaps facilitator, the U.S. firm finds an Australian firm, Party B, that faces the same situation in reverse. They wish to issue AUD debt and swap into a USD exposure.

There are **four possible types of currency swaps** available.

1. Party A pays a fixed rate on AUD received, and Party B pays a fixed rate on USD received.

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2. Party A pays a floating rate on AUD received, and Party B pays a fixed rate on USD received.

3. Party A pays a fixed rate on AUD received, and Party B pays a floating rate on USD received.

4. Party A pays a floating rate on AUD received, and Party B pays a floating rate on USD received.

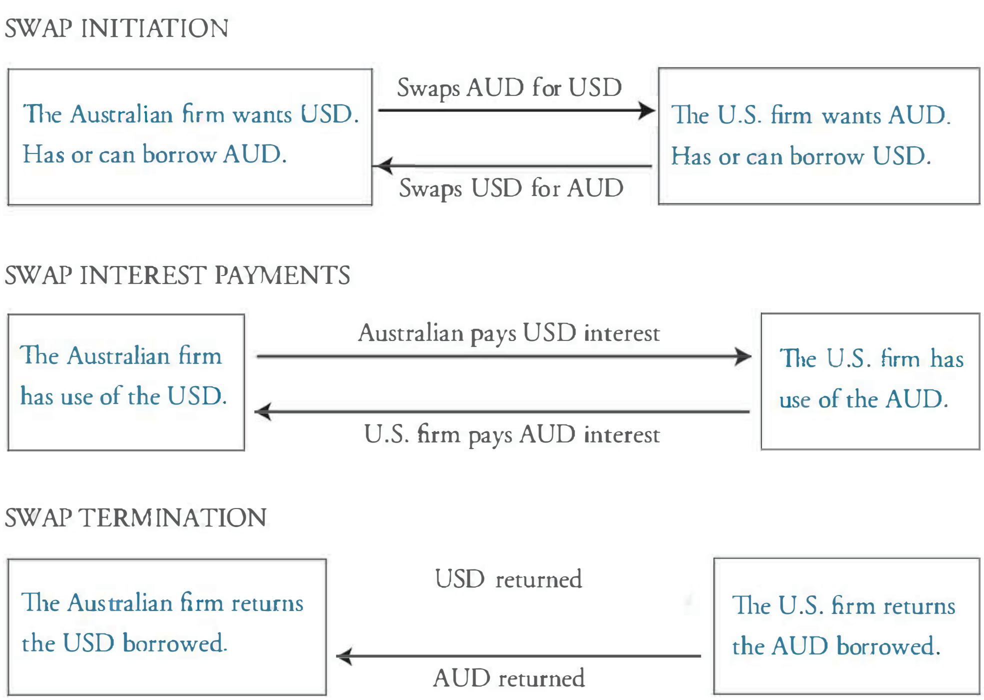
Following are the steps in a fixed-for-fixed currency swap:

Step 1: The notional principal actually changes hands at the beginning of the swap. Party A gives USD to Party B and gets AUD back. Why? Because the motivation of Party A was to get AUD and the motivation of Party B was to get USD. *Notional principal is swapped at initiation.*

Step 2: Interest payments are made without netting. Party A, who got AUD, pays the Australian interest rate on the notional amount of AUD to Party B. Party B, who got USD, pays the U.S. interest rate on the notional amount of USD received to Party A. Since the payments are made in different currencies, netting is not a typical practice. *Full interest payments are exchanged at each settlement date, each in a different currency.*

Step 3: At the termination of the swap agreement (maturity), the counterparties give each other back the exchanged notional amounts. *Notional principal is swapped again at the termination of the agreement.* The cash flows associated with this currency swap are illustrated in Figure 1.

Figure 1: Fixed-for-Fixed Currency Swap



Calculating the Payments on a Currency Swap

Example: Fixed-for-fixed currency swap

BB can borrow in the United States for 9%, while AA has to pay 10% to borrow in the United States. AA can borrow in Australia for 7%, while BB has to pay 8% to borrow in Australia. BB will be doing business in Australia and needs AUD, while AA will be doing business in the United States and needs USD. The exchange rate is 2AUD/USD. AA needs USD1.0 million and BB needs AUD2.0 million. They decide to borrow the funds locally and swap the borrowed funds, charging each other the rate the other party would have paid had they borrowed in the foreign market. The swap period is for five years. Calculate the cash flows for this swap.

Answer:

AA and BB each go to their own domestic bank:

- AA borrows AUD2.0 million, agreeing to pay the bank 7%, or AUD140,000 annually.
- BB borrows USD1.0 million, agreeing to pay the bank 9%, or USD90,000 annually.

AA and BB swap currencies:

- AA gets USD1.0 million, agreeing to pay BB 10% interest in USD annually.
- BB gets AUD2.0 million, agreeing to pay AA 8% interest in AUD annually.

They pay each other the annual interest:

- AA owes BB USD100,000 in interest to be paid on each settlement date.
- BB owes AA AUD160,000 in interest to be paid on each settlement date.

They each owe their own bank the annual interest payment:

- AA pays the Australian bank AUD140,000 (but gets AUD160,000 from BB, an AUD20,000 gain).
- BB pays the U.S. bank USD90,000 (but gets USD100,000 from AA, a USD10,000 gain).
- They both gain by swapping (AA is ahead AUD20,000 and BB is ahead USD 10,000).

In five years, they reverse the swap. They return the notional principal.

- AA gets AUD2.0 million from BB and then pays back the Australian bank.
- BB gets USD1.0 million from AA and then pays back the U.S. bank.

Interest Rate Swaps

The **plain vanilla interest rate swap** involves trading fixed interest rate payments for floating-rate payments. (A **basis swap** involves trading one set of floating rate payments for another.)

The party who wants floating-rate interest payments agrees to pay fixed-rate interest and has the *pay-fixed* side of the swap. The counterparty, who receives the fixed payments and agrees to pay variable-rate interest, has the *pay-floating* side of the swap and is called the *floating-rate payer.*

The floating rate quoted is generally the **London Interbank Offered Rate** (LIBOR), flat or plus a spread.

Let's look at the cash flows that occur in a *plain vanilla interest rate swap*.

- Because the notional principal swapped is the same for both counterparties and is in the same currency units, there is no need to actually exchange the cash. *Notional principal is generally not swapped* in single currency swaps.
- The determination of the variable rate is at the beginning of the settlement period, and the cash interest payment is made at the end of the settlement period. Because the interest payments are in the same currency, there is no need for both counterparties to actually transfer the cash. The difference between the fixed-rate payment and the variable-rate payment is calculated and paid to the appropriate counterparty. *Net interest is paid by the one who owes it.*
- At the conclusion of the swap, since the notional principal was not swapped, there is no transfer of funds.

You should note that swaps are a zero-sum game. What one party gains, the other party loses.

The net formula for the *fixed-rate payer,* based on a 360-day year and a floating rate of LIBOR is:

$$(\text{net fixed-rate payment})_t = (\text{swap fixed rate} - \text{LIBOR}_{t-1})\left(\frac{\text{number of days}}{360}\right)(\text{notional principal})$$

If this number is positive, the fixed-rate payer *owes* a net payment to the floating-rate party. If this number is negative, then the fixed-rate payer *receives* a net flow from the floating-rate payer.

Professor's Note: For the exam, remember that with plain vanilla swaps, one party pays fixed and the other pays a floating rate. Sometimes swap payments are based on a 365-day year. For example, the swap will specify whether 90/360 or 90/365 should be used to calculate a quarterly swap payment. Remember, these are custom instruments.

Example: Interest rate risk

Consider a bank. Its deposits represent liabilities and are most likely short term in nature. In other words, deposits represent floating-rate liabilities. The bank assets are primarily loans. Most loans carry fixed rates of interest. The bank assets are fixed-rate and bank liabilities are floating. Explain the nature of the interest rate risk that the bank faces, and describe how an interest rate swap may be used to hedge this risk.

Answer:

The risk the bank faces is that short-term interest rates will rise, causing cash payment on deposits to increase. This would not be a major problem if cash inflows also increase as interest rates rise, but with a fixed-rate loan portfolio they will not. If the bank remains unhedged as interest rates rise, cash outflows rise and bank profits fall.

The bank can hedge this risk by entering into a fixed-for-floating swap as the fixed-rate payer. The floating-rate payments received would offset any increase in the floating-rate payments on deposits. Note that if rates fall, the bank's costs do not. They still pay fixed for the term of the swap and receive (lower) floating-rate payments that correspond to their lower costs on deposits.

Calculating the Payments on an Interest Rate Swap

Example: Calculating the payments on an interest rate swap

Bank A enters into a $1,000,000 quarterly-pay plain vanilla interest rate swap as the fixed-rate payer at a fixed rate of 6% based on a 360-day year. The floating-rate payer agrees to pay 90-day LIBOR plus a 1% margin; 90-day LIBOR is currently 4%.

90-day LIBOR rates are:	4.5%	90 days from now
	5.0%	180 days from now
	5.5%	270 days from now
	6.0%	360 days from now

Calculate the amounts Bank A pays or receives 90, 270, and 360 days from now.

Answer:

The payment 90 days from now depends on current LIBOR and the fixed rate (don't forget the 1% margin).

Fixed-rate payer pays:

$$\left[0.06\left(\frac{90}{360}\right)-(0.04+0.01)\left(\frac{90}{360}\right)\right]\times 1{,}000{,}000=\$2{,}500$$

270 days from now, the payment is based on LIBOR 180 days from now, which is 5%. Adding the 1% margin makes the floating-rate 6%, which is equal to the fixed rate, so there is no net third quarterly payment.

The bank's "payment" 360 days from now is:

$$\left[0.06\left(\frac{90}{360}\right)-(0.055+0.01)\left(\frac{90}{360}\right)\right]\times 1{,}000{,}000=-\$1{,}250$$

Because the floating-rate payment exceeds the fixed-rate payment, Bank A will *receive* \$1,250 at the fourth payment date.

Equity Swaps

In an **equity swap**, the return on a stock, a portfolio, or a stock index is paid each period by one party in return for a fixed-rate or floating-rate payment. The return can be the capital appreciation or the total return including dividends on the stock, portfolio, or index.

In order to reduce equity risk, a portfolio manager might enter into a 1-year quarterly-pay S&P 500 index swap and agree to receive a fixed rate. The percentage increase in the index each quarter is netted against the fixed rate to determine the payment to be made. If the index return is negative, the fixed-rate payer must also pay the percentage decline in the index to the portfolio manager. Uniquely among swaps, equity swap payments can be floating on both sides and the payments are not known until the end of the quarter. With interest rate swaps, both the fixed and floating payments are known at the beginning of period for which they will be paid.

A swap on a single stock can be motivated by a desire to protect the value of a position over the period of the swap. To protect a large capital gain in a single stock, and to avoid a sale for tax or control reasons, an investor could enter into an equity swap as the equity-returns payer and receive a fixed rate in return. Any decline in the stock price would be paid to the investor at the settlement dates, plus the fixed-rate payment. If the stock appreciates, the investor must pay the appreciation less the fixed payment.

Calculating the Payments on an Equity Swap

Example: Equity swap payments

Ms. Smith enters into a 2-year $10 million quarterly swap as the fixed payer and will receive the index return on the S&P 500. The fixed rate is 8%, and the index is currently at 986. At the end of the next three quarters, the index level is: 1030, 968, and 989.

Calculate the net payment for each of the next three quarters and identify the direction of the payment.

Answer:

The percentage change in the index each quarter, Q, is: Q1 = 4.46%, Q2 = –6.02%, and Q3 = 2.17%. The index return payer will receive 0.08 / 4 = 2% each quarter and pay the index return, therefore:

Q1: Index return payer pays 4.46% – 2.00% = 2.46% or $246,000.
Q2: Index return payer receives 6.02% + 2.00% = 8.02% or $802,000.
Q3: Index return payer pays 2.17% – 2.00% = 0.17% or $17,000.

Key Concepts

LOS 64.a

Swaps are based on a notional amount of principal. Each party is obligated to pay a percentage return on the notional amount at periodic settlement dates over the life (tenor) of the swap. Percentage payments are based on a floating rate, fixed rate, or the return on an equity index or portfolio.

Except in the case of a currency swap, no money changes hands at the inception of the swap and periodic payments are netted (the party that owes the larger amount pays the difference to the other).

Swaps are custom instruments, are largely unregulated, do not trade in secondary markets, and are subject to counterparty (default) risk.

Swaps can be terminated prior to their stated termination dates by:

- Entering into an offsetting swap, sometimes by exercising a swaption (most common).
- Agreeing with the counterparty to terminate (likely involves making or receiving compensation).
- Selling the swap to a third party with the consent of the original counterparty (uncommon).

LOS 64.b

In a plain vanilla (fixed-for-floating) interest-rate swap, one party agrees to pay a floating rate of interest on the notional amount and the counterparty agrees to pay a fixed rate of interest.

The formula for the net payment by the fixed-rate payer, based on a 360-day year and the number of days in the settlement period is:

$$\begin{aligned}&(\text{net fixed rate payment})_t\\&=(\text{swap fixed rate} - \text{LIBOR}_{t-1})\left(\frac{\text{number of days}}{360}\right)(\text{notional principal})\end{aligned}$$

In an equity swap, the returns payer makes payments based on the return on a stock, portfolio, or index, in exchange for fixed- or floating-rate payments. If the stock, portfolio, or index, declines in value over the period, the returns payer receives the interest payment and a payment based on the percentage decline in value.

In a currency swap, the notional principal (in two different currencies) is exchanged at the inception of the swap, periodic interest payments in two different currencies are exchanged on settlement dates, and the same notional amounts are exchanged (repaid) on the termination date of the swap.

Concept Checkers

1. Which of the following statements about swaps is *least likely* correct?
   A. In an interest rate swap, the notional principal is swapped.
   B. The default problem is the most important limitation to the swap market.
   C. In a plain vanilla interest rate swap, fixed rates are traded for variable rates.

2. Which of the following statements about swaps is *least likely* correct?
   A. The time frame of a swap is called its tenor.
   B. In a currency swap, only net interest payments are made.
   C. In a currency swap, the notional principal is actually swapped twice, once at the beginning of the swap and again at the termination of the swap.

3. Which of the following statements is *least likely* an advantage of swaps? Swaps:
   A. have little or no regulation.
   B. minimize default risk.
   C. have customized contracts.

4. In an equity swap:
   A. settlement is made only at swap termination.
   B. shares are exchanged for the notional principal.
   C. returns on an index can be swapped for fixed-rate payments.

5. In a plain vanilla interest rate swap:
   A. the notional principal is swapped.
   B. only the net interest payments are made.
   C. the notional principal is returned at the end of the swap.

6. Which of the following statements about swap markets is *least likely* correct?
   A. In an interest rate swap only the net interest is exchanged.
   B. The notional principal is swapped at inception and at termination of a currency swap.
   C. Only the net difference between the dollar interest and the foreign interest is exchanged in a currency swap.

Use the following data to answer Questions 7 through 10.

Consider a 3-year annual currency swap that takes place between a foreign firm (FF) with FC currency units and a U.S. firm (USF) with $ currency units. USF is the fixed-rate payer and FF is the floating-rate payer. The fixed interest rate at the initiation of the swap is 7%, and 8% at the end of the swap. The variable rate is 5% currently; 6% at the end of year 1; 8% at the end of year 2; and 7% at the end of year 3. At the beginning of the swap, $1.0 million is exchanged at an exchange rate of FC2.0 = $1.0. At the end of the swap period, the exchange rate is FC 1.5 = $1.0.

Note: With this currency swap, end-of-period payments are based on beginning-of-period interest rates.

7. At the initiation of the swap, which of the following statements is *most likely* correct?
   A. FF gives USF $1.0 million.
   B. USF gives FF $1.0 million.
   C. USF gives FF FC2.0 million.

8. At the end of year 2:
   A. USF pays FC140,000; FF pays $60,000.
   B. USF pays FC60,000; FF pays $70,000.
   C. USF pays USD70,000; FF pays FC60,000.

9. At the termination of the swap, FF gives USF which of the following notional amounts?
   A. $1 million.
   B. FC2,000,000.
   C. FC1,500,000.

10. At the end of year 3, FF will pay which of the following total amounts?
    A. $1,080,000.
    B. $1,070,000.
    C. FC2,160,000

Use the following information to answer Questions 11 through 13.

Lambda Corp. has a floating-rate liability and wants a fixed-rate exposure. They enter into a 2-year quarterly-pay $4,000,000 fixed-for-floating swap as the fixed-rate payer. The counterparty is Gamma Corp. The fixed rate is 6% and the floating rate is 90-day LIBOR + 1%, with both calculated based on a 360-day year. Realizations of LIBOR are:

Annualized LIBOR	
Current	5.0%
In 1 quarter	5.5%
In 2 quarters	5.4%
In 3 quarters	5.8%
In 4 quarters	6.0%

11. The first swap payment is:
    A. from Gamma to Lambda.
    B. known at the initiation of the swap.
    C. $5,000.

12. The second net swap payment is:
    A. $5,000 from Lambda to Gamma.
    B. $4,000 from Gamma to Lambda.
    C. $5,000 from Gamma to Lambda.

13. The fifth net quarterly payment on the swap is:
    A. 0.
    B. $10,000.
    C. $40,000.

Answers – Concept Checkers

1. A In an interest rate swap, the notional principal is only used to calculate the interest payments and does not change hands. The notional principal is only exchanged in a currency swap.

2. B In a currency swap, payments are not netted because they are made in different currencies. Full interest payments are made, and the notional principal is also exchanged.

3. B Swaps do not minimize default risk. Swaps are agreements between two or more parties, and there are no guarantees that one of the parties will not default. Note that swaps do give traders privacy and, being private transactions, have little to no regulation and offer the ability to customize contracts to specific needs.

4. C Equity swaps involve one party paying the return or total return on a stock or index periodically in exchange for a fixed return.

5. B In a plain vanilla interest rate swap, interest payments are netted. Note that notional principal is not exchanged and is only used as a basis for calculating interest payments.

6. C In a currency swap, full interest payments are made, and the notional principal is exchanged.

7. B Because this is a currency swap, we know that the notional principal is exchanged. Because USF holds dollars, it will be handing over dollars to FF.

8. A Remember, the currency swap is pay floating on dollars and pay fixed on foreign. Floating at the end of year 1 is 6% of \$1.0 million. Since payments are made in arrears, FF pays \$60,000 and USF pays FC140,000 at the end of year 2.

9. A The notional principal is exchanged at termination. FF gives back what it borrowed, \$1.0 million, and the terminal exchange rate is not used.

10. A FF is the floating-rate dollar payer. FF will pay the return of \$1.0 million in principal at the termination of the swap, plus the floating rate payment (in arrears) of 8% × \$1.0 million = \$80,000. The total payment will be \$1,080,000.

11. B The first payment is based on the fixed rate and current LIBOR + 1%, which are both 6%. There is no net payment made at the first quarterly payment date and this is known at the initiation of the swap.

12. C The second quarter payment is based on the realization of LIBOR at the end of the first quarter, 5.5%. The floating rate is: $(5.5\% + 1\%)\left(\frac{90}{360}\right)4{,}000{,}000 = \$65{,}000$. The fixed rate payment is \$60,000, making the net payment \$5,000 from Gamma to Lambda.

13. B The fifth quarterly floating-rate payment is based on the realization of LIBOR at the end of the fourth quarter, which is 6%. With the 1% margin, the floating rate is 7% compared to 6% fixed, so the net payment is \$10,000.

The following is a review of the Derivatives principles designed to address the learning outcome statements set forth by CFA Institute. This topic is also covered in:

Risk Management Applications of Option Strategies

Study Session 17

Exam Focus

The most important aspect of this topic review is the interpretation of option profit diagrams. Payoff diagrams for single put or single call positions were covered in our options review. In this review, we introduce profit diagrams and two option strategies that combine stock with options. In a protective put position, we combine a share of stock and a put. With this strategy, we essentially purchase downside protection for the stock (like insurance). A covered call position consists of buying a share of stock and selling a call on it. This strategy equates to selling the upside potential on the stock in return for the added income from the sale of the call. On the Level I CFA® Exam, you will not be required to draw payoff diagrams, but you are expected to know how to interpret them and find the breakeven price, maximum gains and losses, and the gains and losses for any stock price at option expiration.

LOS 65.a: Determine the value at expiration, the profit, maximum profit, maximum loss, breakeven underlying price at expiration, and payoff graph of the strategies of buying and selling calls and puts and determine the potential outcomes for investors using these strategies.

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Call Option Profits and Losses

Consider a call option with a premium of $5 and a strike price of $50. This means the buyer pays $5 to the writer. At expiration, if the price of the stock is less than or equal to the $50 strike price (the option has zero value), the buyer of the option is out $5, and the writer of the option is ahead $5. As the stock's price exceeds $50, the buyer of the option starts to gain (breakeven will come at $55, when the value of the stock equals the strike price and the option premium). However, as the price of the stock moves upward, the seller of the option starts to lose (negative figures will start at $55, when the value of the stock equals the strike price and the option premium).

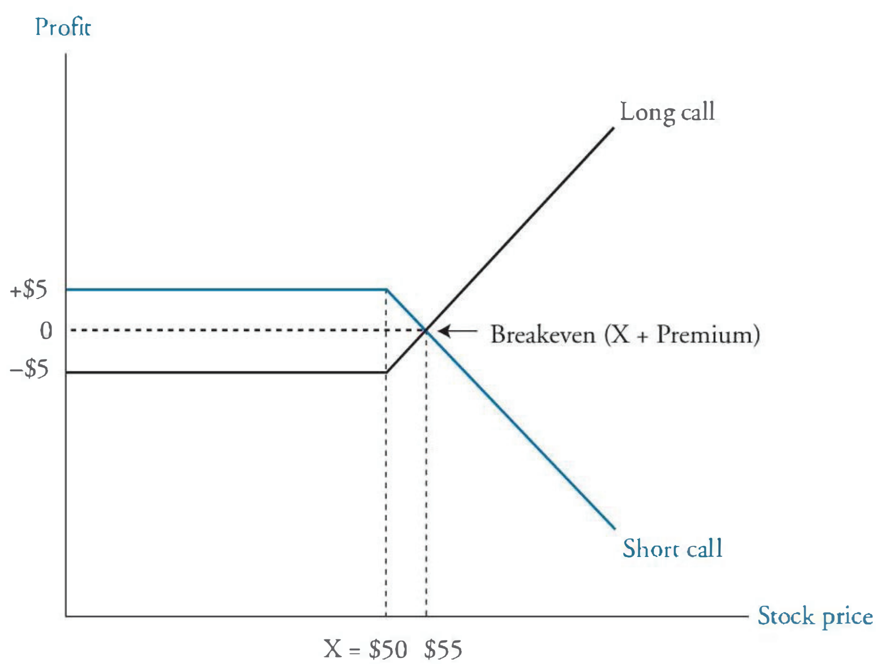
The profit/loss diagram for the buyer (long) and writer (short) of the call option we have been discussing at expiration is presented in Figure 1. This profit/loss diagram illustrates the following:

- The maximum loss for the buyer of a call is the loss of the $5 premium (at any $S \leq \$50$).
- The breakeven point for the buyer and seller is the strike price plus the premium (at $S = \$55$).

- The profit potential to the buyer of the option is unlimited, and, conversely, the potential loss to the writer of the call option is unlimited.
- The call holder will exercise the option whenever the stock's price exceeds the strike price at the expiration date.
- The greatest profit the writer can make is the $5 premium (at any S ≤ $50).
- The sum of the profits between the buyer and seller of the call option is always zero; thus, options trading is a *zero-sum game*. There are no net profits or losses in the market. The long profits equal the short losses.

Professor's Note: Please notice that option profit diagrams show the gain or loss to the long and/or short option positions. They differ from the payoff diagrams that we used in our options review in that profit diagrams reflect the cost of the option (i.e., the option premium).

Figure 1: Profit/Loss Diagram for a Call Option



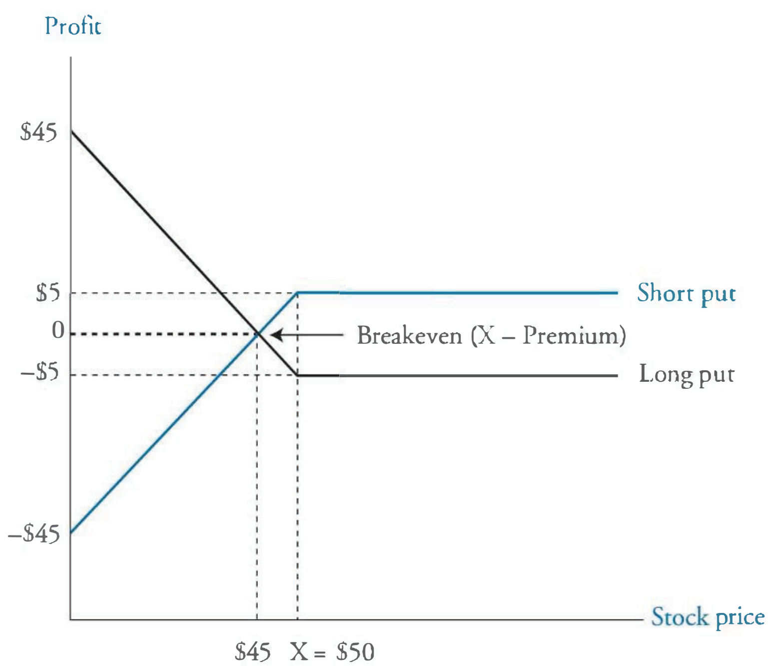
Put Option Profits and Losses

To examine the profits/losses associated with trading put options, consider a put option with a $5 premium. The buyer pays $5 to the writer. When the price of the stock at expiration is greater than or equal to the $50 strike price, the put has zero value. The buyer of the option has a loss of $5, and the writer of the option has a gain of $5. As the stock's price falls below $50, the buyer of the put option starts to gain (breakeven will come at $45, when the value of the stock equals the strike price less the option premium). However, as the price of the stock moves downward, the seller of the option starts to lose (negative profits will start at $45, when the value of the stock equals the strike price less the option premium).

Figure 2 shows the profit/loss diagram for the buyer (long) and seller (short) of the put option that we have been discussing. This profit/loss diagram illustrates that:

- The maximum loss for the buyer of a put is the loss of the $5 premium (at any S ≥ $50).
- The maximum gain to the buyer of a put is limited to the strike price less the premium ($50 – $5 = $45). The potential loss to the writer of the put is the same amount.
- The breakeven price of a put buyer (seller) is at the strike price minus the option premium ($50 – $5 = $45).
- The greatest profit the writer of a put can make is the $5 premium (S ≥ $50).
- The sum of the profits between the buyer and seller of the put option is always zero. Trading put options is a *zero-sum game*. In other words, the buyer's profits equal the writer's losses.

Figure 2: Profit/Loss Diagram for a Put Option



Example: Option profit calculations

Suppose that both a call option and a put option have been written on a stock with an exercise price of $40. The current stock price is $42, and the call and put premiums are $3 and $0.75, respectively.

Calculate the profit to the long and short positions for both the put and the call with an expiration day stock price of $35 and with a price at expiration of $43.

Answer:

Profit will be computed as ending option valuation – initial option cost.

Stock at $35:

- Long call: $0 – $3 = –$3. The option finished out-of-the-money, so the premium is lost.
- Short call: $3 – $0 = $3. Because the option finished out-of-the-money, the call writer's gain equals the premium.
- Long put: $5 – $0.75 = $4.25. You paid $0.75 for an option that is now worth $5.
- Short put: $0.75 – $5 = –$4.25. You received $0.75 for writing the option, but you face a $5 loss because the option is in-the-money.

Stock at $43:

- Long call: –$3 + $3 = $0. You paid $3 for the option, and it is now worth $3. Hence, your net profit is zero.
- Short call: $3 – $3 = $0. You received $3 for writing the option and now face a –$3 valuation for a net profit of zero.
- Long put: –$0.75 – $0 = –$0.75. You paid $0.75 for the put option and the option is now worthless. Your net profit is –$0.75.
- Short put: $0.75 – $0 = $0.75. You received $0.75 for writing the option and keep the premium because the option finished out-of-the-money.

A buyer of puts or a seller of calls will profit when the price of the underlying asset decreases. A buyer of calls or a seller of puts will profit when the price of the underlying asset increases. In general, a put buyer believes the underlying asset is overvalued and will decline in price, while a call buyer anticipates an increase in the underlying asset's price.

LOS 65.b: Determine the value at expiration, profit, maximum profit, maximum loss, breakeven underlying price at expiration, and payoff graph of a covered call strategy and a protective put strategy, and explain the risk management application of each strategy.

CFA® Program Curriculum, Volume 6, page 151

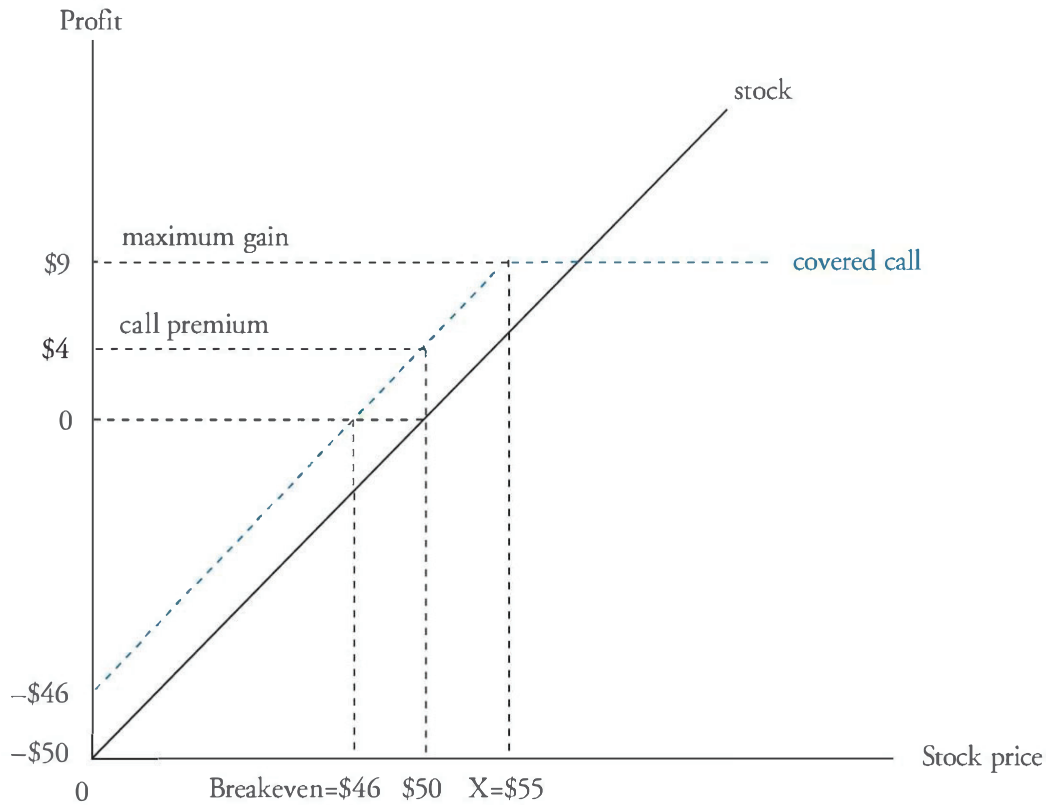
Professor's Note: Whenever we combine options with assets or other options, the net cost of the combined position is simply the sum of the prices paid for the long options/assets minus the proceeds from the option/asset sales (short positions). The profits and losses on a position are simply the value of all the assets/options in the positions at expiration minus the net cost.

In writing **covered** calls, the term *covered* means that owning the stock covers the obligation to deliver stock assumed in writing the call. Why would you write a covered call? You feel the stock's price will not go up any time soon, and you want to increase your income by collecting the call option premium. To add some insurance that the stock won't get called away, the call writer can write out-of-the-money calls. You should know that this strategy for enhancing one's income is not without risk. *The call writer is trading the stock's upside potential for the call premium.*

Figure 3 illustrates the profit/loss of a covered call position at option expiration date. When the call was written, the stock's price was $50. The call's strike price was $55, and the call premium was $4. The call is out-of-the-money. From Figure 3, we can observe that at expiration:

- If the stock closes below $50, the option will expire worthless, and the option writer's loss is offset by the premium income of $4.
- Breakeven *for the position* is at $46 = $50 – $4. Breakeven price = S_0 – call premium.
- If the stock closes between $50 and $55, the option will expire worthless. Because this option was an out-of-the-money call, the option writer will get any stock appreciation above the original stock price and below the strike price. So the gain (premium plus stock appreciation) will be between $4 and $9.
- If stock closes above $55, the strike price, the writer will get nothing more. The maximum gain is $9 on the covered out-of-the-money call.
- The maximum loss occurs if the stock price goes to zero; the net cost of the position ($46 = $50 stock loss offset by $4 premium income) is the maximum loss.

Figure 3: Covered Call Profit and Loss for S = 50, C = 4, X = 55



The desirability of writing a covered call to enhance income depends upon the chance that the stock price will exceed the exercise price at which the trader writes the call. In this example, the writer of the call thinks the stock's upside potential is less than the buyer expects. The buyer of the call is paying $4 to get any gain above $55, while the seller has traded the upside potential above $55 for a payment of $4.

A **protective** put is an investment management technique designed to protect a stock from a decline in value. It is constructed by buying a stock and put option on that stock.

Look at the profit/loss diagrams in Figure 4. The diagram on the left is the profit from holding the stock. If the stock's value is up, your profit is positive and if the stock's value is down, your profit is negative. Profit equals the end price, S_T, less the initial price S_t. That is, profit = $S_T - S_t$. The diagram on the right side of Figure 4 is the profit graph from holding a long put. If the market is up, you lose your premium payment, and if the market is down, you have a profit.

The value of the put at termination will be $\max[0, X - S_T]$. Your profit will be $\max[0, X - S_T]$ less the price of the put.

Figure 4: Protective Put Components

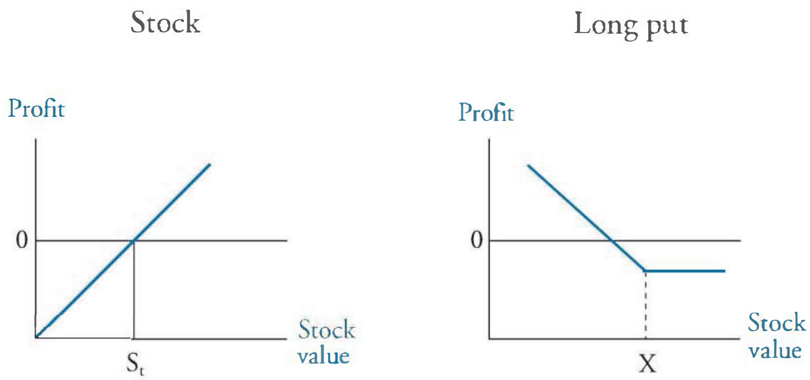
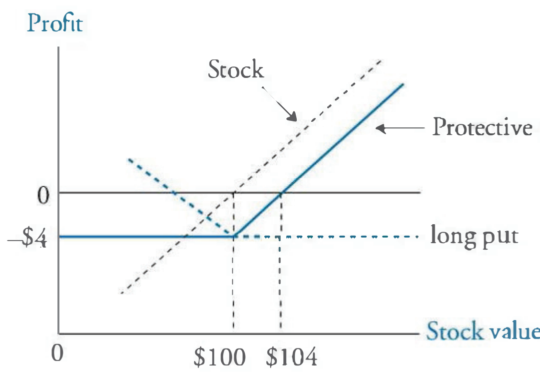


Figure 5 shows the profits from the combination of a long put and a long stock (i.e., a protective put). Here it is assumed that the stock is purchased at $100 and that a put with a strike price of $100 is purchased for $4. Note that the put described in Figure 5 is at the money.

Figure 5: Protective Put



What we should observe in Figure 5 is that:

- A protective put cuts your downside losses (maximum loss = $4) but leaves the upside potential alone (unlimited upside gains).
- Your maximum loss occurs at any price below $100.
- Losses between $0 and $4 occur for stock prices between $100 and $104.
- You will not make a profit until the stock price exceeds $104 (breakeven).
- Breakeven price = S_0 + premium.

Note that *a protective put (stock plus a put) has the same shape profit diagram as a long call.* It could be replicated with a bond that pays (X – premium) at expiration and a call at X.

Professor's Note: Recall that this relation was the basis for our derivation of put-call parity. The payoffs at expiration are identical for a protective put (S + P) and a fiduciary call $\left[\frac{X}{(1+R_f)^{T-t}}+C\right]$, *a call with an exercise price equal to* X *and a pure discount bond that pays* X *at expiration.*

Study Session 17

KEY CONCEPTS

LOS 65.a

Call option value at expiration is Max (0, S – X) and profit (loss) is Max (0, S – X) – option cost.

	Call Option	
	Maximum Loss	*Maximum Gain*
Buyer (long)	Option Cost	Unlimited
Seller (short)	Unlimited	Option Cost
Breakeven	X + Option Cost	

Put value at expiration is Max (0, X – S) and profit (loss) is Max (0, X – S) – option cost.

	Put Option	
	Maximum Loss	*Maximum Gain*
Buyer (long)	Option Cost	X – Option Cost
Seller (short)	X – Option Cost	Option Cost
Breakeven	X – Option Cost	

A call buyer (call seller) anticipates an increase (decrease) in the value of the underlying asset.

A put buyer (put seller) anticipates a decrease (increase) in the value of the underlying asset.

LOS 65.b

A covered call position is a share of stock and a short (written) call. Profits and losses are measured relative to the net cost of this combination (S_0 – premium).

- The purpose of selling a covered call is to enhance income by trading the stock's upside potential for the call premium.
- The upside potential on a covered call is limited to ($X - S_0$) + call premium received. The maximum loss is the net cost (S_0 – premium).

A protective put consists of buying a share of stock and buying a put. Profits and losses are measured relative to the net cost (S_0 + premium).

- A protective put is a strategy to protect against a decline in the value of the stock.
- Maximum gains on a protective put are unlimited, but reduced by the put premium paid. Maximum losses are limited to ($S_0 - X$) + put premium paid.

CONCEPT CHECKERS

1. A call option sells for $4 on a $25 stock with a strike price of $30. Which of the following statements is *least accurate*?
   A. At expiration, the buyer of the call will not make a profit unless the stock's price exceeds $30.
   B. At expiration, the writer of the call will only experience a net loss if the price of the stock exceeds $34.
   C. A covered call position at these prices has a maximum gain of $9 and the maximum loss of the stock price less the premium.

2. An investor buys a put on a stock selling for $60, with a strike price of $55 for a $5 premium. The maximum gain is:
   A. $50.
   B. $55.
   C. $60.

3. Which of the following is the riskiest single-option transaction?
   A. Writing a call.
   B. Buying a put.
   C. Writing a put.

4. An investor will *likely* exercise a put option when the price of the stock is:
   A. above the strike price.
   B. below the strike price plus the premium.
   C. below the strike price.

5. A put with a strike price of $75 sells for $10. Which of the following statements is *least accurate*? The greatest:
   A. profit the writer of the put option can make is $10.
   B. profit the buyer of a put option can make is $65.
   C. loss the writer of a put option can have is $75.

6. At expiration, the value of a call option must equal:
   A. the larger of the strike price less the stock price or zero.
   B. the stock price minus the strike price, or arbitrage will occur.
   C. the larger of zero, or the stock's price less the strike price.

7. An investor writes a covered call on a $40 stock with an exercise price of $50 for a premium of $2. The investor's maximum:
   A. gain will be $12.
   B. loss will be $40.
   C. loss will be unlimited.

8. Which of the following combinations of options and underlying investments have similarly shaped profit/loss diagrams? A:
   A. covered call, and a short stock combined with a long call.
   B. short put option combined with a long call option, and a protective put.
   C. long call option combined with a short put option, and a long stock position.

Answers – Concept Checkers

1. A The buyer will not have a net profit unless the stock price exceeds $34 (strike price plus the premium). The other statements are true. At $30 the option will be exercised, but the writer will only lose money in a net sense when the stock's price exceeds X + C = $30 + $4. The covered call's maximum gain is $4 premium plus $5 appreciation.

2. A This assumes the price of the stock falls to zero and you get to sell for $55. Your profit would be $55 – 5 = $50.

3. A When buying either a call or a put, the loss is limited to the amount of the premium. When writing a put, the loss is limited to the strike price if the stock falls to zero (however, the writer keeps the premium). When writing an uncovered call, the stock could go up infinitely, and the writer would be forced to buy the stock in the open market and deliver at the strike price—potential losses are unlimited.

4. C The owner of a put profits when the stock falls. The put would be exercised when the price of the stock is *below* the strike price. The amount of the premium is used to determine net profits to each party.

5. C The greatest loss the put writer can have is the strike price minus the premium received equals $65. The other statements are true. The greatest profit the put writer can make is the amount of the premium. The greatest profit for a put buyer occurs if the stock falls to zero and the buyer makes the strike price minus the premium. Since options are a zero-sum game, the maximum profit to the writer of the put must equal the maximum loss to the buyer of the put.

6. C At expiration, the value of a call must be equal to its intrinsic value, which is Max[0, S – X]. If the value of the stock is less than the strike price, the intrinsic value is zero. If the value of the stock is greater than the strike price, the call is in-the-money and the value of the call is the stock price minus the strike price, or S – X.

7. A As soon as the stock rises to the exercise price, the covered call writer will cease to realize a profit because the short call moves into-the-money. Each dollar gain on the stock is then offset with a dollar loss on the short call. Since the option is $10 out-of-the-money, the covered call writer can gain this amount plus the $2 call premium. Thus, the maximum gain is $2 + $10 = $12. However, because the investor owns the stock, he or she could lose $40 if the stock goes to zero, but gain $2 from the call premium. Maximum loss is $38.

8. C A combined long call and a short put, with exercise prices equal to the current stock price, will have profits/losses at expiration nearly identical to those of a long stock position.

Professor's Note: The easiest way to see this is to draw the payoff diagram for the combined option positions.