Derivatives

Study Session 17

Weight on Exam	5%
SchweserNotes™ Reference	Book 5, Pages 151–200

Derivative Markets and Instruments

Cross-Reference to CFA Institute Assigned Reading #57

Overview of Derivative Contracts

A *derivative* is a security that *derives* its value from the value of, or return on, another asset or security. A physical exchange exists for many options contracts and futures contracts. Exchange-traded derivatives are standardized and backed by a clearinghouse.

Forwards and *swaps* are custom instruments traded/created by dealers in a market with no central location. A dealer market with no central location is referred to as an over-the-counter market. They are largely unregulated markets, and each contract is with a counterparty, which exposes the owner of a derivative to default risk (when the counterparty does not honor their commitment).

Some *options* trade in the over-the-counter market, notably bond options.

A **forward commitment** is a legally binding promise to perform some action in the future. Forward commitments include forward contracts, futures contracts, and swaps. Forward contracts and futures contracts can be written on equities, indexes, bonds, foreign currencies, physical assets, or interest rates.

A **contingent claim** is a claim (to a payoff) that depends on a particular event. Options are contingent claims that depend on a stock price at some future date.

Credit derivatives are contingent claims that depend on a credit event such as a default or ratings downgrade.

The criticism of derivatives is that they are “too risky,” especially to investors with limited knowledge of sometimes complex instruments. Because of the high leverage involved in derivatives payoffs, they are sometimes likened to gambling.

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The benefits of derivatives markets are that they:

- Provide price information.
- Allow risk to be managed and shifted among market participants.
- Reduce transactions costs.

Forward Contracts

In a forward contract, one party agrees to buy and the counterparty to sell a physical or financial asset at a specific price on a specific date in the future. A forward contract can be used to reduce or eliminate uncertainty about the future price of an asset (hedge) or to speculate on movements in asset prices.

Typically, neither party to the contract makes a payment at the initiation of a forward contract. If the expected future price of the asset increases over the life of the contract, the right to buy at the forward price (the long) will have positive value, and the obligation to sell (the short) will have an equal negative value.

If the expected future price of the asset falls below the forward price, the result is opposite and the right to sell (at an above-market price) will have a positive value.

A deliverable forward contract is settled by the short delivering the underlying asset to the long. Other forward contracts are settled in cash. In a cash-settled forward contract, one party pays cash to the other when the contract expires based on the difference between the forward price and the market price of the underlying asset at the settlement date.

Futures Contracts

Futures contracts are similar to forward contracts in that both:

- Can be either deliverable or cash-settled contracts.
- Have contract prices set so each side of the contract has a value of zero at the initiation of the contract.

Futures contracts differ from forward contracts in the following ways:

- Futures contracts trade on organized exchanges. Forwards are private contracts and typically do not trade.
- Futures contracts are standardized. Forwards are customized contracts satisfying the specific needs of the parties involved.
- A clearinghouse is the counterparty to all futures contracts. Forwards are contracts with the originating counterparty and, therefore, have counterparty (credit) risk.
- The government regulates futures markets. Forward contracts are usually not regulated and do not trade in organized markets.

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The **settlement price** 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. It is used to calculate the daily gain or loss at the end of each trading day. On its final day of trading, the settlement price is equal to the spot price of the underlying asset.

As with forwards, the buyer of a futures contract has a long position, while the seller of a futures contract has a short position. For each contract traded, there is a buyer (long) and a seller (short).

Open interest is the number of futures contracts of a specific kind outstanding at any given time. Open interest increases when traders enter new long and short positions and decreases when traders exit existing positions.

Speculators use futures contracts to gain exposure to changes in the price of the asset underlying a futures contract. In contrast, **hedgers** use futures contracts to reduce an existing exposure to price changes in the asset.

Each futures exchange has a **clearinghouse**. It guarantees traders in the futures market will honor their obligations by acting 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. The guarantee of the clearinghouse removes counterparty risk from futures contracts.

In the futures markets, margin must be deposited by both the long and the short as a performance guarantee prior to entering into a futures contract. This provides protection for the clearinghouse. Each day, the margin balance in a futures account is marked to market; that is, gains are added to the margin account and losses deducted.

Initial margin is the amount that must be deposited in a futures account before a trade may be made.

Maintenance margin is the minimum amount of margin that must be maintained. If the margin balance in the account falls below the maintenance margin, additional funds must be deposited to bring the margin balance back up to the initial margin amount. Margin requirements are set by the clearinghouse.

Exchange members are prohibited from executing trades at prices outside set price 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.

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Swaps

Swaps are agreements to exchange a series of payments on periodic *settlement dates* over a certain time period. 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.

Swaps are similar to forwards in several ways:

- 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.

In a **plain vanilla interest rate swap**:

- One party makes fixed-rate interest payments on a notional principal amount specified in the swap in return for floating-rate payments from the other party.
- The party who wants floating-rate interest payments agrees to pay fixed-rate interest and has the *pay-fixed* side of the swap. The other party is known as the *pay-floating* side.
- The payments owed by one party to the other are based on a notional principal that is stated in the swap contract.

In a **basis swap**, one set of floating-rate payments is swapped for another.

Options

An option contract gives its owner the right, but not the obligation, to either buy or sell an underlying asset at a given price (the exercise price or strike price). The option buyer can choose whether to exercise an option, whereas the seller is obligated to perform if the buyer exercises the option. 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.

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The price of an option is also referred to as the option premium.

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.

Credit Derivatives

A credit derivative is a contract that provides a bondholder (lender) with protection against a downgrade or a default by the borrower.

A **credit default swap** (CDS) is an insurance contract against default. A bondholder pays a series of cash flows to a credit protection seller and receives a payment if the bond issuer defaults.

A **credit spread option** is typically a call option that is based on a bond's yield spread relative to a benchmark. If the bond's credit quality decreases, its yield spread will increase and the bondholder will collect a payoff on the option.

Arbitrage

Arbitrage opportunities arise when assets are mispriced. Trading by arbitrageurs will continue until they affect supply and demand enough to bring asset prices to efficient (no-arbitrage) levels.

There are two arbitrage arguments that are particularly useful in the study and use of derivatives:

1. The first is based on the "law of one price." Two securities or portfolios that have identical cash flows in the future, regardless of future events, should have the same price. If A and B have identical future payoffs, and A is priced lower than B, buy A and sell B.

2. The second type of arbitrage is used when two securities with uncertain returns can be combined in a portfolio that will have a certain payoff. If a portfolio consisting of A and B has a certain payoff, the portfolio should yield the risk-free rate.

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Basics of Derivative Pricing and Valuation

Cross-Reference to CFA Institute Assigned Reading #58

No-Arbitrage Valuation

Typically, we value a risky asset by calculating the present value of its expected future cash flows using a discount rate that depends on the risk of the expected cash flows and the risk aversion of investors.

In contrast, we value **derivative securities** based on a no-arbitrage condition. We can **replicate** the cash flows from a risky asset with a portfolio that includes a derivative security. Unless the asset and the portfolio that replicates its cash flows sell at the same price, there is an **arbitrage opportunity** to sell the one with the higher price and buy the one with the lower price. Arbitrage opportunities will be rapidly exploited so the prices of derivative securities are driven to their **no-arbitrage values**. In practice, arbitrage will ensure that derivatives prices deviate from their no-arbitrage values by no more than the transaction costs of executing the arbitrage strategy.

With a long and short position in an asset and a replicating portfolio, the payoffs on this *hedged* portfolio are certain, so investor risk aversion does not affect the value of the hedged portfolio or the value of the derivative. Because of this, we sometimes refer to this method as **risk-neutral pricing**.

As a simple example of a hedged portfolio, consider a long position in a risky asset selling for S_0 and a short forward contract on the asset at a forward price of $F_0(T)$. If there are no costs or benefits to holding the asset, the cost of buying the asset and holding it until settlement of the forward contract at time T is simply S_0 plus the opportunity cost of the funds for the period, $S_0\ (1 + Rf)^T$.

The forward hedge requires the asset be sold for $F_0(T)$ at time T so there is no arbitrage opportunity if the forward contract is priced so that $F_0(T) = S_0\ (1 + Rf)^T$, the opportunity cost of buying and holding the asset until time T.

If the equality holds, the derivative is currently at its no-arbitrage price. As the spot price, risk-free rate, and certain payoff at time T are all known, the equation can be used to solve for the no-arbitrage price of the derivative.

In general, with "+" a long position and "–" a short position, we have:

risky asset + derivative = risk free asset

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so that

risky asset – risk free asset = – derivative position

derivative position – risk free asset = – risky asset

Pricing and Valuing Derivatives

The *price* of a derivative is the price or interest rate specified in the contract. At initiation, the derivative price is typically set so that the *value* of the derivative is zero. During the life of the derivative contract, increases in the spot price of the underlying asset increase the value of a long derivative position, and decreases in the spot price of the asset decrease the value of a long derivative position.

Previously, we explained the no-arbitrage relation for a forward contract on an asset with no storage costs or benefits to holding it. In this case, the *net cost of carry* is the opportunity cost of invested funds, which we assume to be the risk-free rate, Rf. Based on the condition of no-arbitrage, the forward price at contract initiation must be:

$$F_0(T) = S_0(1 + Rf)^T$$

If the forward price were $F_0(T)+ > S_0(1 + Rf)^T$, an arbitrageur could:

- Take a short position in (sell) the forward contract.
- Buy the asset at S_0, with funds borrowed at Rf.

At time *T*, the arbitrageur would deliver the asset and receive $F_0(T)+$, repay the loan at a cost of $S_0(1 + Rf)^T$, and keep the difference between $F_0(T)+$ and $S_0(1 + Rf)^T$.

If the forward price were $F_0(T)- < S_0(1 + Rf)^T$, an arbitrageur could:

- Take a long position in (buy) the forward contract.
- Short sell the asset and invest the proceeds at Rf.

At time *T*, the arbitrageur would receive $S_0(1 + Rf)^T$ from investing the proceeds of the short sale, pay $F_0(T)$ to purchase the asset (to cover the short position), and keep the difference between $S_0(1 + Rf)^T$ and $F_0(T)-$.

This process is the mechanism that ensures $F_0(T)$ is the (no-arbitrage) price in a forward contract that has zero value at t = 0.

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Valuing a forward contract. At initiation:

$$V_0(T) = S_0 - \frac{F_0(T)}{(1+Rf)^T} = 0, \text{ because } S_0 = \frac{F_0(T)}{(1+Rf)^T}$$

At any time = t prior to settlement, t < T, the value of the forward is the spot price of the asset minus the present value of the forward price:

$$V_t(T) = S_t - \frac{F_0(T)}{(1+Rf)^{T-t}}$$

At settlement, the payoff to a long forward position is:

$$S_T - F_0(T)$$

Holding Costs and Benefits

In addition to the opportunity cost of the funds, Rf, there may be costs of holding an asset such as storage and insurance costs, especially with physical assets.

There also may be benefits to holding the asset. These benefits may be *monetary* if the asset makes cash payments (e.g., interest, dividends) over the life of the derivative. There may also be *nonmonetary* benefits to owning an asset (e.g., ability to sell it) that we refer to as the asset's **convenience yield**.

Denoting the present value of any costs of holding the asset as PV_0(cost) and the present value of cash flows and convenience yield as PV_0(benefit), the no-arbitrage price becomes:

$$F_0(T) = [S_0 + PV_0(\text{cost}) - PV_0(\text{benefit})]\ (1 + Rf)^T$$

Here we have replaced the spot price of the asset with its cost adjusted for the present value of the costs and benefits of holding it until time = T.

Note that, for a given spot price, greater benefits of owning the asset decrease the no-arbitrage forward price and greater costs of holding the asset increase the no-arbitrage forward price.

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The value of the forward at any point in time t < T becomes:

$$V_t(T) = S_t + PV_t(\text{cost}) - PV_t(\text{benefit}) - \frac{F_0(T)}{(1+Rf)^{T-t}}$$

At settlement there are no further costs or benefits, so once again the value at time = T is:

$$V_t(T) = S_T - F_0(T)$$

Forward Rate Agreements

A **forward rate agreement** (FRA) is a derivative contract that has an interest rate, rather than an asset price, as its underlying. An FRA permits an investor to lock in a certain interest rate for borrowing or lending at some future date. One party will pay the other party the difference (based on an agreed-upon notional contract value) between the interest rate specified in the FRA and the market interest rate at contract settlement.

LIBOR is most often used as the underlying rate. U.S. dollar LIBOR refers to the rates on Eurodollar time deposits, interbank U.S. dollar loans in London.

Consider an FRA that will, in 30 days, pay the difference between 90-day LIBOR and the 90-day rate specified in the FRA (the contract rate).

- A company that expects to borrow 90-day funds in 30 days will have higher interest costs if 90-day LIBOR increases over the next 30 days.
- A long position in an FRA (to "borrow" at the fixed rate) will receive a payment at settlement that will offset the increase in borrowing costs from the increase in 90-day LIBOR.
- Conversely, if 90-day LIBOR decreases over the next 30 days, the long position in the FRA will make a payment to the short in the amount that the company's borrowing costs have decreased relative to the FRA contract rate.

Firms can, therefore, reduce or eliminate the risk of (uncertainty about) future borrowing costs using an FRA.

Similarly, a firm that expects to lend (deposit) funds for 90 days, 30 days from now, can take a short position in an FRA. If the future 90-day LIBOR decreases, the return on the loan decreases, but this is offset by a payment received from the long FRA position.

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Rather than enter into an FRA, a bank can create the same payment structure (a **synthetic FRA**) with two LIBOR loans (e.g., by borrowing money for 120 days and lending that amount for 30 days). By these transactions, the bank receives the funds from the repayment of the 30-day loan and has use of these funds for the next 90 days at an effective rate determined by the original transactions. The effective rate of interest on this 90-day loan depends on both 30-day LIBOR and 120-day LIBOR at the time the money is borrowed and loaned. This rate is the contract rate on a 30-day FRA on 90-day LIBOR. The resulting cash flows will be the same with either an FRA or its synthetic equivalent.

Forward versus Futures Prices

Futures contracts are standardized, traded, liquid contracts that are marked to market at the end of each trading day. Based on the change in the futures price from the previous day, gains are added to, and losses subtracted from, the balance in the investor's margin account. If losses reduce the margin balance below the minimum margin level, funds must be deposited to bring the margin balance back to its initial required level or the position will be closed out.

Forward contracts typically are not marked to market during their lives. This difference in valuation is only relevant in practice if futures prices are correlated with interest rates.

If the price of the underlying asset is positively correlated with interest rates, long futures positions will generate cash when rates are higher and require funds when rates are lower, with a net positive effect on the value of a futures position, so that futures prices will be higher than forward prices. Futures prices will be lower when asset prices and interest rates have negative correlation.

If rates are uncorrelated with futures prices, or rates are constant, forward and futures prices will be the same.

Swaps

In a simple interest-rate swap, one party pays a floating rate (LIBOR) and the other pays a fixed rate on a notional principal amount. For example, on a one-year swap with quarterly settlement dates, the difference between the swap fixed rate and LIBOR (for the *prior* 90 days) is paid by the party who owes more at each settlement date.

We can replicate each of these payments to (or from) the fixed-rate payer in the swap with a forward contract. A long position in an FRA will replicate the position

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of the fixed-rate payer: the long will receive a payment when LIBOR is above the forward rate and pay when LIBOR is below the forward rate.

An interest rate swap is, therefore, equivalent to a series of forward rate agreements, each with a forward contract rate equal to the swap fixed rate. However, there is one important difference. Because the forward contract rates are all equal in the FRAs that are equivalent to the swap, these would not be zero-value forward contracts at the initiation of the swap.

When a forward contract is created with a contract rate that gives it a non-zero value at initiation, it is called an **off-market forward**. Some, if not all, of the forward contracts that comprise a swap will almost certainly be off-market forwards. Because a swap has zero value to both parties at initiation, the values of the individual off-market forwards must sum to zero.

The swap fixed rate (which is also the contract rate for the off-market forwards) that gives the swap a zero value at initiation can be found using the principle of no-arbitrage pricing.

The fixed-rate payer in a swap can replicate that derivative position by borrowing at a fixed rate and lending the proceeds at a variable (floating) rate.

As with forward rate agreements, the price of a swap is the fixed rate of interest specified in the swap contract (the contract rate), and the value depends on how expected future floating rates change over time.

At initiation, a swap has zero value because the present value of the fixed-rate payments equals the present value of the expected floating-rate payments. An increase in expected short-term future rates will produce a positive value for the fixed-rate payer in an interest rate swap, and a decrease in expected future rates will produce a negative value because the promised fixed-rate payments have more value than the expected floating-rate payments over the life of the swap.

Options: Moneyness, Intrinsic Value, Time Value

An option that would provide a positive payoff if exercised is said to be **in the money**. The **intrinsic value** of an option is the amount that it is in the money or zero if the option is at- or out-of-the-money. The difference between the price of an option (called its premium) and its intrinsic value is termed its **time value**. Hence:

option premium = intrinsic value + time value

The following table summarizes the moneyness of options based on the stock's current price, *S*, and the option's exercise price, *X*.

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

Factors Determining European Option Values

Price of the Underlying Asset

An increase in the price of the underlying asset will increase the value of a call option, and a decrease in the price of the underlying asset will decrease the value of a call option.

An increase in the price of the underlying asset will decrease the value of a put option, and a decrease in the price of the underlying asset will increase the value of a put option.

The Exercise Price

A higher exercise price decreases the values of call options, and a lower exercise price increases the values of call options.

A higher exercise price increases the values of put options, and a lower exercise price decreases the values of put options.

The Risk-Free Rate of Interest

For options on assets other than bonds, an increase in the risk-free rate will increase call values, and a decrease in the risk-free rate will decrease call values.

An increase in the risk-free rate will decrease put option values, and a decrease in the risk-free rate will increase put option values.

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Volatility of the Underlying

An increase in the volatility of the price of the underlying asset increases the values of both put and call options and a decrease in volatility of the price of the underlying decreases both put values and call values.

Time to Expiration

Longer time to expiration increases expected volatility of the asset price over the option's life and increases the value of call options. Less time to expiration decreases the value of call options.

For most put options, longer time to expiration will increase option values because expected volatility is greater with longer time to expiration. For some European put options, however, extending the time to expiration can decrease the value of the put because the intrinsic value will be paid in the future and its present value decreases with longer time to expiration.

In general, the deeper a put option is in the money, the higher the risk-free rate; the longer the current time to expiration, the more likely that extending a put option's time to expiration will decrease its value.

Costs and Benefits of Holding the Asset

If there are benefits of holding the underlying asset (dividend or interest payments on securities or a convenience yield on commodities), call values are decreased and put values are increased.

An increase in storage costs for an asset has the opposite effect: increasing call values and decreasing put values. Call values increase because owning a call option becomes relatively more attractive than holding the asset itself when storage costs increase. Put values fall because buying and holding the asset for future delivery at the put price becomes more expensive.

Put-Call Parity for European Options

Put-call parity is based on the no-arbitrage principle that portfolios with identical payoffs must sell for the same price. A **fiduciary call** (composed of a European call option and a risk-free bond that will pay X at expiration) and a **protective put** (composed of a share of stock and a long put) both have identical payoffs at

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maturity regardless of value of the underlying asset at expiration. Based on this fact and the law of one price, we can state that, for European options:

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

That is, the value of a call at *X* and the present value of the exercise price must equal the current asset price plus the value of a put or there would be an opportunity for profitable arbitrage. Using just a bit of algebra, we can also state that:

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

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

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

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

The single securities on the left-hand side of the equations all have exactly the same payoffs at expiration 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, *X*, for these relations to hold.

If these equalities do not hold, buying the "cheap" side of the equation and selling the other "expensive" side will produce an immediate riskless arbitrage profit.

Put-Call Forward Parity for European Options

Put-call forward parity is derived with a forward contract rather than the underlying asset itself. A forward contract on an asset at time *T* has zero value at initiation; therefore, a long forward at a price of $F_0(T)$, combined with a bond that pays the forward price, $F_0(T)$, at the settlement date is equivalent to owning the asset at settlement. The cost of this position is simply the present value of $F_0(T)$, or $F_0(T) / (1 + Rf)^T$. Because this is a way to own the asset at expiration, we can

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substitute this value for the current price of the asset in put-call parity for European options and get:

$$F_0(T) / (1 + Rf)^T + p_0 = c_0 + X / (1 + Rf)^T$$

which is put-call forward parity at time 0, the initiation of the forward contract, based on the principle of no arbitrage. By rearranging the terms, put-call forward parity can also be expressed as:

$$p_0 - c_0 = [X - F_0(T)] / (1 + Rf)^T$$

Binomial Model

In a binomial model, an asset price will change to one of two possible values (a movement either up or down) over the next period. The inputs required are:

- Beginning asset value.
- Size of up and down movements.
- Risk-neutral probabilities of up and down movements.

The risk-neutral probabilities of an up and down move are calculated as:

$$\pi_U = \text{risk-neutral probability of an up-move} = \frac{1 + R_f - D}{}$$

$$\pi_U = \text{risk-neutral probability of aa down-move} = 1 - \pi_U$$

where:
R_f = risk-free rate
U = size of an up-move
D = size of a down-move

Note that these are not the actual probabilities of an up-move or a down-move but the probabilities that apply if we are to discount the expected payoff on the asset at the risk-free rate. Determining the value of an option using a binomial model requires that we:

- Calculate the payoffs of the option at the end of the period for both an up-move and down-move.
- Calculate the expected value of the option in one year as the probability-weighted average of the payoffs in each state.
- Discount this expected value back to today at the risk-free rate.

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European versus American Option Values

The only difference between European and American options is that a holder of an American option has the right to exercise prior to expiration, while European options can only be exercised at expiration.

For a call option on an asset that has no cash flows during the life of the option, there is no advantage to early exercise. Thus, otherwise identical American and European call options on assets with no cash flows will have the same value.

If the underlying asset makes cash payments (e.g., pays a dividend) during the life of a call option, the price of an American call option will be greater than the price of otherwise identical European call options. A cash payment will decrease the value of the asset and reduce the value of a European call. Early exercise of an American option may be valuable as it allows exercise of the call before the cash distribution is made.

For put options, cash flows on the underlying do not make early exercise valuable because a decrease in the price of the underlying asset when it makes a cash distribution would increase the value of a put option. In the case of a put option that is deep in the money, however, early exercise may be advantageous. Consider the extreme case of a put option on a stock that has fallen in value to zero. Exercising the put will result in an immediate payment of the exercise price. For a European put option, this payment cannot be received until option expiration, so its value now is the present value of that exercise price. Given the potential positive value of early exercise for put options, American put options can be priced higher than otherwise identical European put options.

Risk Management Applications of Option Strategies

Cross-Reference to CFA Institute Assigned Reading #59

The key here is your ability to interpret option payoff diagrams. It is absolutely critical that you understand each option payoff diagram and be able to make the appropriate computations for option payoffs and the payoffs for the included option strategies (e.g., a covered call).

- Buyer of a call option—long position.
- Writer (seller) of a call option—short position.
- Buyer of a put option—long position.
- Writer (seller) of a put option—short position.

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Call Option Payoff Diagrams

The following graph illustrates the payoff at expiration for a call option as a function of the stock price, for both buyers and writers. Note that this differs from the *profit diagram* that follows in that the profit diagram reflects the initial cost of the option (the *premium*). Remember that the option buyer pays the premium to the option seller and if the option finishes out of the money, the writer keeps the premium and the buyer loses the premium. Options are considered a *zero-sum game* because whatever amount the buyer gains, the seller loses, and vice versa.

intrinsic value of a call option = max[0, S – X] intrinsic value of a put option = max[0, X – S]

Figure 1: Call Option Payoff Diagram

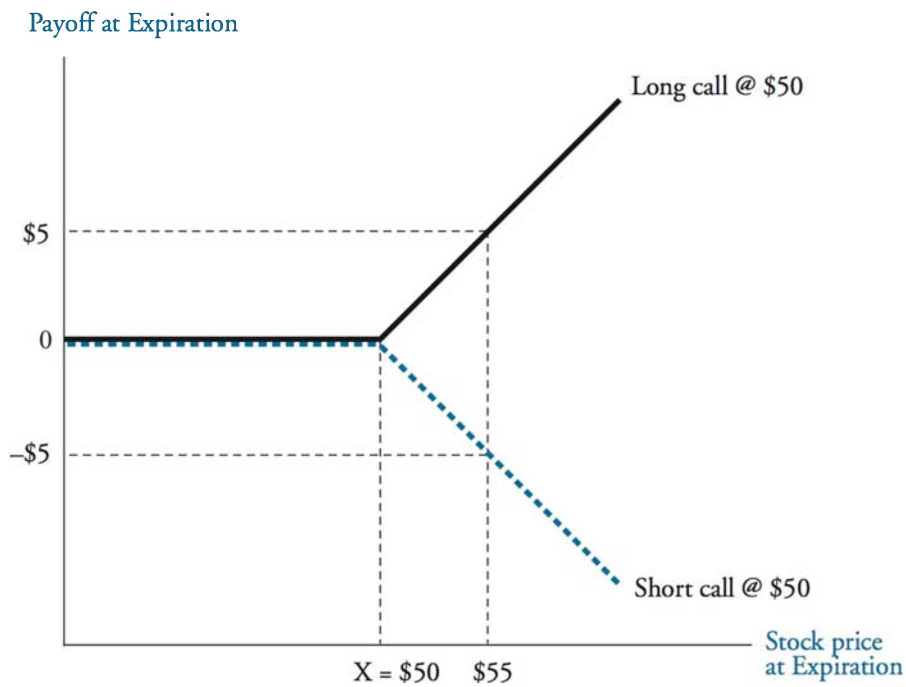
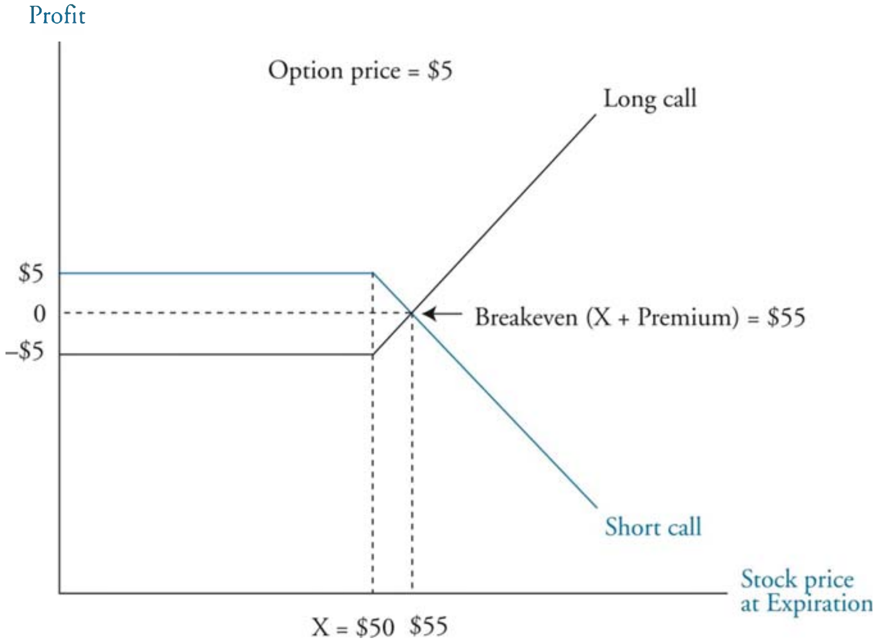


Figure 2: Profit/Loss Diagram for a Call Option



For a *call option:*

$$\text{breakeven}_{\text{call}} = \text{strike price} + \text{premium}$$

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

Put Option Diagrams

The following graph illustrates the payoff at expiration for a put option as a function of stock price, for both buyers and writers.

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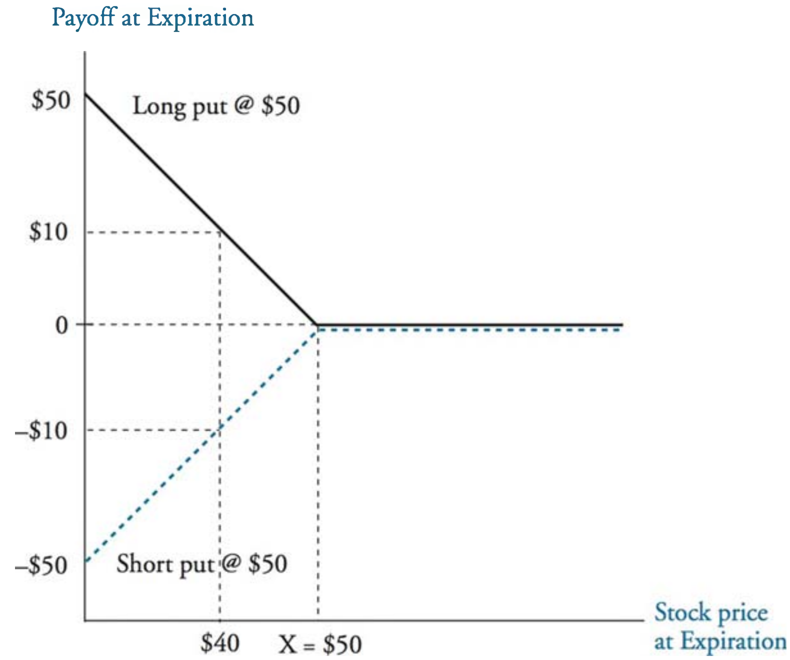
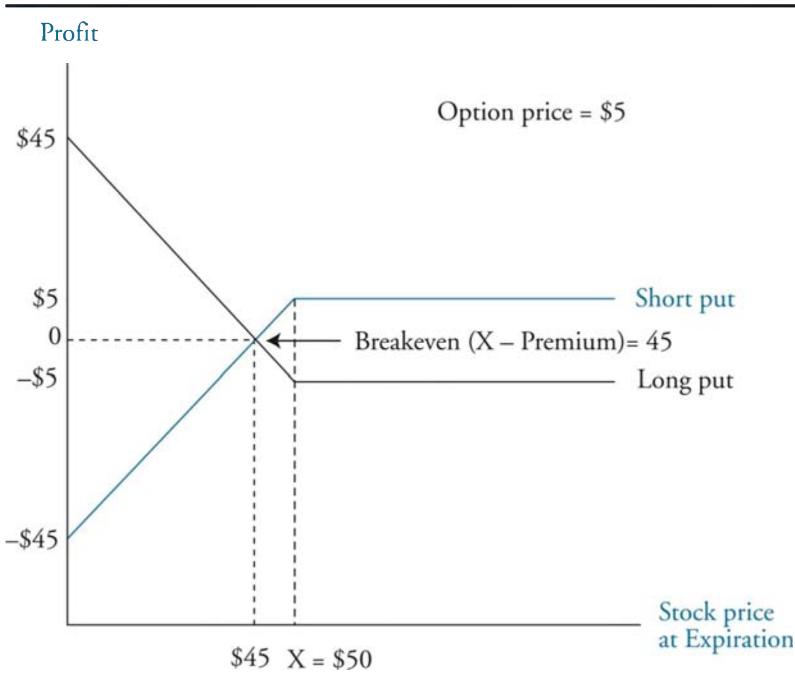
Figure 3: Put Option Payoff Diagram



Note that in the *profit diagram* that follows, the cost of the option (the *premium*) is included.

Figure 4: Profit/Loss Diagram for a Put Option



For a *put option:*

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

Covered Calls, Protective Puts

A *covered call* is the combination of a long stock and a short call. The term *covered* means that the stock covers the inherent obligation 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 some call option premiums. This strategy for enhancing income is not without risk. The call writer is trading the stock's upside potential above the strike price for the call premium.

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. Any gain on the stock at option expiration is reduced by the put premium paid. The combined (protective put) position will produce profits at option expiration only if the stock price exceeds the sum of the purchase prices of the stock and the put. If the stock price at option expiration is below the put's strike price, the put payoff will limit the maximum loss to the difference between the cost of the position and the strike price of the put.

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