

Investment Analysis & Portfolio Management

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Discussion topics

Option contracts

- Basic definitions and illustration of option contracts
- Types of options
- Principles of option pricing
- Discrete-time option pricing: The Binomial Model
- Continuous-time option pricing: The Black-Scholes-Merton model



Readings

 CFA Program Curriculum 2015 -Level II – Volume 6: Derivatives and Portfolio Management.

Reading 49

 Don M. Chance and Robert Brooks, An Introduction to Derivatives and Risk Management, 9th Edition, 2013, Thomson.



Chapters 3-5

Definition

A contract that gives its holder the *right*, not the obligation, to buy or sell an underlying asset at a fixed price by a certain time in the future. The party granting the right is called option seller (or the short or option writer)



Parties in an option contract

- The long (also called option buyer or option holder) holds the right to buy/sell the underlying.
- The short (also called option seller or option writer) grants the right to the long party.

Call

An option granting the right to buy the underlying.

Put

An option granting the right to sell the underlying.

Option price

- To obtain the right to buy/sell the underlying, the option buyer pays the seller a sum of money, commonly referred to as the option price (or the option premium or just the premium).
- The money is paid when the option contract is initiated.



- Exercise price (also called strike price, striking price, or strike)
 - It is the fixed price at which the option holder can buy or sell the underlying.
- Exercise (or exercising) the option
 - Use of the right to buy or sell the underlying.
- Expiration date
 - When the expiration date arrives, an option that is not exercised simply expires.

Exercising a call

- The buyer pays the exercise price and receives either the underlying or an equivalent cash settlement.
- The seller, who receives the exercise price from the buyer and delivers the underlying, or alternatively, pays an equivalent cash settlement.



Exercising a put

- The buyer delivers the stock and receives the exercise price or an equivalent cash settlement.
- The seller receives the underlying and must pay the exercise price or the equivalent cash settlement.



Cash settlement

- The option holder exercising a call receives the difference between the market value of the underlying and the exercise price from the seller in cash.
- The option holder exercising a put receives the difference between the exercise price and the market value of the underlying in cash.

European-style exercise

- The option can be exercised only on its expiration day.
- American-style exercise
 - The option can be exercised on any day through the expiration day.



Exchange-listed, standardized options

The exchange specifies a designated number of units of the underlying, and other terms of an option contract (e.g., expiration dates, exercise prices, minimum price quotation unit, exercising style, settlement style, and contract size), with the exception of price that will be negotiated by two parties.

- Exchange-listed, standardized options
 - Standardized options are traded on exchanges.
 - Some exchanges have pit trading, whereby parties meet in the pit and arrange a transaction.
 - Some exchanges use electronic trading, in which transactions are conducted through computers.
 - Transactions are guaranteed by the clearinghouse, i.e., the clearing house will step in and fulfill the obligation if the seller reneges at exercise.

- Exchange-listed, standardized options
 - The majority of trading occurs in options that are close to being at-the-money. Options that are far in-the-money or far out-of-the-money, called deep-in-the-money and deep-out-of-the-money options, are usually not very actively traded and are often not even listed for trading.
 - Most exchange-listed options have fairly shortterm expirations, usually the current month, the next month, and perhaps one or two other months.

Exchange-listed, standardized options

Defaults are rare.

When the buyer purchases the option, the premium, which one might think would go to the seller, instead goes to the clearinghouse, which maintains it in the margin account. In addition, the seller must post some margin money, which is based on a formula that reflects whether the seller has a position that hedges the risk and whether the option is in- or out-of-the-money. Although defaults are rare, the clearinghouse has always been successful in paying when the seller defaults.

Exchange-listed, standardized options

On the expiration day

In-the-money options are always exercised, assuming they are in-the-money by more than the transaction cost of buying or selling the underlying or arranging a cash settlement when exercising.

Over-the-counter options

- An over-the-counter option is created off of an exchange by any two parties who agree to trade.
 - The buyer is subject to the possibility of the writer defaulting, but not the other way around.
- Brokers in the market attempt to match buyers of options with sellers, thereby earning a commission.
- Dealers offer to take either side of the option transaction, usually laying off (hedging) the risk in another transaction.

Over-the-counter options

- Over-the-counter options markets are essentially unregulated. There are no guarantees that the seller will perform; hence, the buyer faces credit risk. As such, option buyers must scrutinize sellers' credit risk and may require some risk reduction measures, such as collateral.
- Contracts can be customized on all terms, such as price, exercise price, time to expiration, deification of the underlying, settlement or delivery, size of the contract, etc.

 Consider some calls and puts on SUNW. The date is 13 June and SUNW is selling for \$16.25. Here are closing prices of four American options:

| Exercise price | July calls | October calls | July puts | October puts |
|-------------------|------------|------------------|-----------|-----------------|
| 15.00 | 2.35 | 3.30 | 0.90 | 1.85 |
| 17.50 | 1.00 | 2.15 | 2.15 | 3.20 |

July 15 call

- This option permits the holder to buy SUNW at a price of \$15 a share any time through 20 July.
- To obtain this option, one would pay a price of \$2.35.
- The seller received \$2.35 on 13 June and must be ready to sell SUNW to the buyer for \$15 during the period through 20 July.
- The option holder has no reason to exercise the option right now.

July 17.50 call

- □ This call is cheaper than the July 15 call.
- The cheaper price comes from the fact that July 17.50 call is less likely to be exercised, because the stock has a higher hurdle to clear.
- A buyer is not willing to pay as much and a seller is more willing to take less for an option that is less likely to be exercised.

October calls

- For any exercise price, October calls would be more expensive than the July calls because they allow a longer period for the stock to make the move that the buyer wants.
- October options are more likely to be exercised than July options; therefore, a buyer would be willing to pay more and the seller would demand more for the October calls.

October 17.50 put

- This option costs \$3.20 and allows the buyer to sell SUNW at a price of \$17.50 any time up through 18 October.
- The buyer has no reason to exercise the option right now, because it would mean he would be buying the option for \$3.20 and selling a stock worth \$16.25 for \$17.50. In effect, the buyer would part with \$19.45 and obtain only \$17.50.
- The buyer of a put obviously must be anticipating that the stock will fall before the expiration day.

October 15 put

- For any exercise price, October calls would be more expensive than the July calls because they allow a longer period for the stock to make the move that the buyer wants.
- October options are more likely to be exercised than July options; therefore, a buyer would be willing to pay more and the seller would demand more for the October calls.

- If at expiration, the stock is at 16.
 - Calls with an exercise price of 15 would be exercised.
 - Actual delivery: The seller delivers the stock and the buyer pays the seller; through the clearinghouse, \$15 per share.
 - Cash settlement: The seller pays the buyer \$1.

Concept of moneyness

Moneyness of options

- In-the-money options are those in which exercising the option would produce a cash inflow that exceeds the cash outflow.
 - Calls are in-the-money when the exercise price exceeds the value of the underlying.
 - Puts are in-the-money when the exercise price exceeds the value of the underlying.
- At-the-money options are those in which exercising the option would produce a zero cash flow.

Concept of moneyness

Moneyness of options

- Out-of-the-money options are those in which exercising the option would produce a cash outflow that exceeds the cash inflow.
- At-the-money options can effectively be viewed as out-of-the-money options because their exercise would not bring in more money than is paid out.
- One would not necessarily exercise an in-themoney option, but one would never exercise an out-of-the-money option.



Stock and index options

Stock options

- Options on individual stocks, also called equity options, are among the most popular.
- Exchanged-listed options are available on most widely traded stocks, and an option on any stock can potentially be created on the over-the-counter market.

Stock and index options

Index options

- An index option is an option on a stock index. A stock index is just an artificial portfolio of stocks.
- Example
 - Consider options on the S&P 500 Index, which trade on the Chicago Board Options Exchange and have a designated index contract multiplier of 250. On 13 June of a given year, the S&P 500 closed at 1,241.60. A call option with an exercise price of \$1,250 expiring on 20 July was selling for \$28. The option is European style and settles in cash.

Stock and index options

Index options

- Example
 - The underlying, the S&P 500, is treated as though it were a share of stock worth \$1,241.60, which can be bought, using the call option, for \$1,250 on 20 July.
 - At expiration, if the option is in-the-money, the buyer exercises it and the writer pays the buyer the \$250 contract multiplier times the difference between the index value at expiration and \$1,250.

Bond options

 Options on bonds are primarily traded in the over-the-counter markets. They are almost always options on government bonds.

- Consider a US T-bond maturing in 27 years. The bond has a coupon of 5.50%, a yield of 5.75%, and is selling for \$0.9659 per \$1 par.
- An over-the-counter call option on this bond with an exercise price of \$0.98 per \$1 par covers \$5 million face value of bonds.

Bond options

- Suppose the buyer exercises the call when the bond price is at \$0.995.
 - The option is in-the-money by \$0.995 \$0.98 = \$0.015 per \$1 par. The buyer would assume the risk of the seller defaulting.
 - Delivery: The seller would deliver \$5 million face value of bonds, which would be worth \$5,000,000(\$0.995) = \$4,975,000. The buyer would pay \$5,000,000(\$0.98) = \$4,900,000.
 - Cash settlement: The seller pays the buyer 0.015(\$5,000,000) = \$75,000.

Definition

An option in which the underlying is an interest rate. It has an exercise rate (or strike rate), which is expressed on an order of magnitude of an interest rate. At expiration, the option payoff is based on the difference between the underlying rate in the market and the exercise rate. Whereas an FRA is a commitment to make one interest payment and receive another at a future date, an interest rate option is the right to make one interest payment and receive another.

Interest rate call

- An option in which the holder has the right to make a known interest payment and receive an unknown interest payment.
- □ The underlying is the unknown interest rate.
- If the unknown underlying rate turns out to be higher than the exercise rate at expiration, the option is in-the-money and is exercised; otherwise, the option simply expires.

Interest rate put

- An option in which the holder has the right to make an unknown interest payment and receive a known interest payment.
- If the unknown underlying rate turns out to be lower than the exercise rate at expiration, the option is in-the-money and is exercised; otherwise, the option simply expires.
- Interest rate options are settled in cash and most tend to be European style.

Example

- Consider an option expiring in 90 days on 180-day Libor. The option buyer chooses an exercise rate of 5.5% and a notional principal of \$10 million.
- On the expiration day, suppose that 180-day Libor is 6%.
 - The call option is in-the-money. The payoff to the holder of the option is:

 $(\$10,000,000)(0.06-0.055)\left(\frac{180}{360}\right) = \$25,000$

 This money is not paid at expiration but will be paid 180 days later

Payoff of an interest rate call

 $\binom{Notional}{Principal}Max \begin{pmatrix} 0, Underlying rate at expiration \\ -Excercise rate \end{pmatrix} \begin{pmatrix} \frac{days in the underlying rate}{360} \end{pmatrix}$

Payoff of an interest rate put

 $\binom{Notional}{Principal}Max\binom{0, Excercise rate}{-Underlying rate at expiration}\binom{days in the underlying rate}{360}$

- Hedging using interest rate options
 - Borrowers often use interest rate call options to hedge the risk of rising rates on floating-rate loans.
 - Lenders often use interest rate put options to hedge the risk of falling rates on floating-rate loans.
 - Since floating-rate loans usually involve multiple interest payments, both borrowers and lenders need options expiring on each rate reset date to hedge.

- Hedging using interest rate options
 - A combination of interest rate calls is referred to as "an interest rate cap" or sometimes just "a cap".
 - A series of call options on an interest rate, with each option expiring at the date on which the floating loan rate will be reset, and with each option having the same exercise rate.
 - Each component call option is called "a caplet".
 - The price of an interest rate cap is the sum of the prices of the options that make up the cap.

Hedging using interest rate options

- A combination of interest rate puts is referred to as "an interest rate floor" or sometimes just "a floor".
 - A series of put options on an interest rate, with each option expiring at the date on which the floating loan rate will be reset, and with each option having the same exercise rate.
 - Each component call option is called "a floorlet"
 - The price of an interest rate floor is the sum of the prices of the options that make up the floor.

Hedging using interest rate options

- A combination of caps and floors is called "an interest rate collar".
 - A combination of a long cap and a short floor or a short cap and a long floor.
- Example
 - Consider a borrower in a floating rate loan who wants to hedge the risk of rising interest rates but is concerned about the requirement that this hedge must have a cash outlay up front: the option premium.

- Hedging using interest rate options
 - Example
 - A collar, which adds a short floor to a long cap, is a way of reducing and even eliminating the up-front cost of the cap. The sale of the floor brings in cash that reduces the cost of the cap.
 - It is possible to set the exercise rates such that the price received for the sale of the floor precisely offsets the price paid for the cap, thereby completely eliminating the up-front cost.

- Hedging using interest rate options
 - Example
 - Although the cap allows the borrower to be paid when rates are high, the sale of the floor requires the borrower to pay the counterparty when rates are low. Thus, the cost of protection against rising rates is the loss of the advantage of falling rates.

Definition

- A currency option allows the holder to buy (if a call) or sell (if a put) an underlying currency at a fixed exercise rate, expressed as an exchange rate.
- Hedging using currency options
 - Many companies, knowing that they will need to convert a currency X at a future date into a currency Y, will buy a call option on currency Y specified in terms of currency X.

Example

□ A US comp-any will be needing €50 million for an expansion project in three months. Thus, it will be buying euros and is exposed to the risk of the euro rising against the dollar. Even though it has that concern, it would also like to benefit if the euro weakens against the dollar. Thus, it might buy a call option on the euro.

- Suppose this call specifies an exercise rate of \$0.90. So the company pays cash up front for the right to buy €50 million at a rate of \$0.90 per euro.
- If the option expires with the euro above 0.90, the company buys euros at \$0.90 and avoid any additional cost over \$0.90.
- If the option expires with the euro below \$0.90, the company does not exercise the option and buys euros at the market rate.

Example

Alternative outcomes

- Dollar expires below €1.1111, that is €1 > \$0.90
 - □ Company sells \$45 million (€50 million × \$0.90) at €1.1111, equivalent to buying €50 million.
- Dollar expires above €1.1111, that is, €1 < \$0.90
 - □ Company sells sufficient dollars to buy €50 million at the market rate.

- The call on the euro can be viewed as a put on the dollar.
 - A call to buy €50 million at an exercise price of \$0.90 is also a put to sell €50 million × \$0.90 = \$45 million at an exercise price of 1/\$0.90, or €1.1111.

Definition

- Options in which the underlying is a futures contract.
 - A call option on futures gives the holder the right to enter into a long futures contract at a fixed futures price.
 - A put option on futures gives the holder the right to enter into a short futures contract at a fixed futures price.

Example

Consider an option on the Eurodollar futures contract trading at the Chicago Mercantile Exchange. On 13 June of a particular year, an option expiring on 13 July was based on the July Eurodollar futures contract. That futures contract expires on 16 July, a few days after the option expires. The call option with exercise price of 95.75 had a price of \$4.60. The underlying futures price was 96.21 (based on a discount rate of 100 -96.21 = 3.79). The contract size is \$1 million.

Example

The buyer of this call option on a futures would pay 0.046(\$1,000,000) = \$46,000 and would obtain the right to buy the July futures contract at a price of 95.75. On the contract initial date, the option was in the money by 96.21 – 95.75 = 0.46 per \$100 face value.

- Suppose that on the expiration date, the futures price is 96.00.
 - The holder of the call would exercise it and obtain a long futures position at a price of 95.75. The price of the underlying futures is 96.00, so the margin account is immediately marked to market with a credit of 0.25 or \$625. The party on the short side of the contract is immediately set up with a short futures contract at the price of 95.75. That party will be charged the \$625 gain that the long has made.

- Suppose that on the expiration date, the futures price is 96.00.
 - If the contract is in-the-money by 96 95.85 = \$0.25 per \$100 par, it is in-the-money by 025/100 = 0.0025, or 0.25% of the face value. Because the face value is \$1 million, the contract is in the money by (0.0025)(90/360)(\$1,000,000) = \$625.
 - Alternatively, the futures price at 95.75 is 1 (0.0425)(90/360) = \$0.989375 per \$1 par, or \$989,375. At 96, the futures price is 1 (0.04)(90/360) = \$0.99 per \$1 par, or \$990,000. The difference is \$625.

- Suppose that on the expiration date, the futures price is 96.00.
 - So, exercising this option is like entering into a futures contract at a price of \$989,375 and having the price immediately go to \$990,000, a gain of \$625. The call holder must deposit money to meet the Eurodollar futures margin, but the exercise of the option gives him \$625. In other words, assuming he meets the minimum initial margin requirement, he is immediately credited with \$625 more.

- Commodity options
 - Options in which the asset underlying the option is a commodity, such as oil, gold, wheat, or soybeans.
 - There are exchange-traded as well as over-thecounter commodity options. Over-the-counter options on oil are widely used.

- Options on electricity, various sources of energy, and weather
 - Electricity is not considered a storable asset because it is produced and almost immediately consumed, but it is nonetheless an asset and certainly has a volatile price. Consequently, it is ideally suited for options and other derivatives trading.



- Options on electricity, various sources of energy, and weather
 - Weather is hardly an asset but simply a random factor that exerts an enormous influence on economic activity. The need to hedge against and speculate on the weather has created a market in which measures of weather activity, such as economic losses from storms or average temperature or rainfall, are structured into a derivative instrument.

- Options on electricity, various sources of energy, and weather
 - Example
 - Consider a company that generates considerable revenue from outdoor summer activities, provided that it does not rain. Obviously a certain amount of rain will occur, but the more rain, the greater the losses for the company. It could buy a call option on the amount of rainfall with the exercise price stated as a quantity of rainfall. If actual rainfall exceeds the exercise price, the company exercises the option and receives the amount of money related to the excess of the rainfall amount over the exercise price.

Real options

A real option is an option associated with the flexibility inherent in capital investment projects. For example, companies may invest in new projects that have the option to defer the full investment, expand, or contract the project at a later date, or even terminate the project. These options do not trade in markets the same way as financial and commodity options, and they must be evaluated much more carefully.



<u>JUESTIONS</u>