CHAPTER 20

Financial Options

Chapter Synopsis

20.1 Option Basics

A financial option gives its owner the right, but not the obligation, to buy or sell a financial asset at a fixed price on or until a specified future date.

- A call option gives the owner the right to buy an asset.
- A put option gives the owner the right to sell the asset.

When a holder of an option enforces the agreement and buys or sells the asset at the agreed-upon price, the holder is said to be exercising an option. The option buyer, or holder, holds the right to exercise the option and has a long position in the contract. The option seller, or writer, sells (or writes) the option and has a short position in the contract. The exercise, or strike, price is the price the contract allows the owner to buy or sell the asset.

The most commonly traded options are written on stocks; however, options on other financial assets also exist, such as options on stock indices like the S&P 500. Using an option to reduce risk is called hedging. Options can also be used to speculate, or bet on the future price of an asset.

American options allow their holders to exercise the option on any date up to and including a final date called the expiration date. European options allow their holders to exercise the option only on the expiration date. Although most traded options are American, European options trade in a few circumstances. For example, European options written on the S&P 500 index exist.

A call option with a strike price below the current stock price is in-the-money, as is a put option with a strike price above the current stock price. Call options with strike prices above the current stock price are out-of-the-money, as are put options with strike prices below the current stock price.
20.2 Option Payoffs at Expiration

The value of a call ($C$) and a put ($P$) at expiration are:

$$C = \max(S - K, 0) \quad \text{and} \quad P = \max(K - S, 0)$$

where $S$ is the stock price at expiration, $K$ is the exercise price, and $\max$ is the maximum of the two quantities in the parentheses.

The writer of a put or call has cash flows that are the opposite of the buyer's cash flows. Because an investor who is long an option will not exercise an option that is out-of-the-money, an option writer can only have a negative payoff once the option is written.

Investors may combine options in a portfolio to undertake various strategies. For example, a straddle involves buying a put and a call at the same exercise price, and can be used by investors who expect the stock to be very volatile and move up or down a large amount, but who do not necessarily have a view on which direction the stock will move. Conversely, investors who expect the stock to end up near the strike price may choose to sell a straddle.

Another strategy, called portfolio insurance, involves using options to ensure that a stock or portfolio does not fall below a certain level.

- If you want to ensure that the value of a stock does not fall below $50, you could buy a protective put with a $50 strike price. If the stock is above $50, you keep the stock, but if it is below $50, you can exercise your put and sell the stock for $50.

- Instead of holding a share of stock and a put, you could get the same payoff by purchasing a risk-free zero coupon bond with a face value of $50 and a European call option with a strike price of $50. In this case, if the stock is below $50, you receive the payoff from the bond; if the stock is above $50, you can exercise the call and use the payoff from the bond to buy the stock for the strike price of $50.

The idea that you can accomplish this same objective two ways is the basis for put-call parity, which is discussed next.

20.3 Put-Call Parity

Consider the two different ways to construct portfolio insurance:

1. Purchase the stock and a put.
2. Purchase a bond and a call.

Because both positions provide exactly the same payoff, the Law of One Price requires that they must have the same price. The relation of the price of a European call option in terms of the price of a European put, the underlying stock, and a zero-coupon bond is known as:

**Put-Call Parity**

$$C = P + S - PV(K) - PV(Div)$$

where $PV(Div)$ is the present value of the stock's future dividends. It says that the price of a European call equals the price of the stock plus an otherwise identical put minus the price of a bond that matures on the exercise date of the option. In other words, you can think of a call as a combination of a levered position in the stock, $S - PV(K)$, plus insurance against a drop in the stock price offered by the put.
20.4 Factors Affecting Options Prices

The intrinsic value of an option is the value it would have if it expired immediately. Options can have values above this value in relation to several boundaries:

- If an American option is worth less than its intrinsic value, arbitrage profits could be made by purchasing the option and immediately exercising it. Thus, an American option cannot be worth less than its intrinsic value, and it cannot be worth less than a European option since it can be exercised at any time.
- A put option cannot be worth more than its strike price because the maximum payoff for a put option occurs if the stock becomes worthless.
- A call option cannot be worth more than the stock itself.

The time value of an option is the difference between the current option price and its intrinsic value.

- For American options, the longer the time to the exercise date, the more valuable the option because of the greater likelihood of very high or very low returns for the stock.
- The value of an option also generally increases with the volatility of the stock because of the greater likelihood of very high or very low returns for the stock.

20.5 Exercising Options Early

The price of a call option on a non-dividend-paying stock always exceeds its intrinsic value. Thus, it is never optimal to exercise a call option on a non-dividend-paying stock early—you are always better off just selling the option. Since the right to exercise the call early is worthless, an American call on a non-dividend-paying stock has the same price as a European call.

The right to exercise an option on dividend-paying stocks early is generally valuable for both calls and puts. Since the price of the stock drops to reflect dividends paid, the value of a call option falls at this time. However, unlike the owner of the stock, the option holder does not get the dividend. Thus, by exercising early and holding the stock, the owner of the call option can capture the dividend. Because a call should only be exercised early to capture the dividend, it will only be optimal to do so just before the stock’s ex-dividend date.

20.6 Options and Corporate Finance

If the firm’s value is below the value of its debt outstanding, the firm must declare bankruptcy, and the equity holders receive nothing. If the firm’s value exceeds the value of the debt, the equity holders get whatever is left once the debt has been repaid. Thus, a share of stock can be thought of as a call option on the assets of a firm with a strike price equal to the value of debt.

Similarly, debt can be thought of as owning the firm and having sold a call option with a strike price equal to the required debt payment. If the value of the firm exceeds the required debt payment, the call will be exercised and the debt holders will receive the required debt payment and give up the firm. If the value of the firm does not exceed the required debt payment, the call will be worthless, the firm will declare bankruptcy, and the debt holders will be entitled to the firm’s assets.
Selected Concepts and Key Terms

American Options
Options that allow their holders to exercise the option on any date up to and including a final date called the expiration date.

At-the-Money Options
Call or put options with strike prices equal to the current stock price.

Call Option
A contract that gives the owner the right (but not the obligation) to buy an asset.

Credit Default Swap (CDS)
In a credit default swap, the buyer pays a premium to the seller (often in the form of periodic payments) and receives a payment from the seller to make up for the loss if the underlying bond defaults. Investment banks developed and began trading CDSs in the late 1990s as a means to allow bond investors to insure the credit risk of the bonds in their portfolios. Many hedge funds and other investors soon began using these contracts as a means to speculate on the prospects of the firm and its likelihood of default even if they did not hold its bonds.

European Options
Options that allow their holders to exercise the option only on the expiration date. Although most traded options are American, European options trade in a few circumstances.

Exercising an Option
When a holder of an option enforces the agreement and buys or sells the share of stock at the agreed-upon price.

Expiration Date
The final date an option can be exercised.

Financial Option
A contract that gives its owner the right, but not the obligation, to purchase or sell a financial asset at a fixed price at some future date.

Hedging with Options
Using an option to reduce risk.

In-the-Money Options
Call options with strike prices above the current stock price, and put options with strike prices below the current stock price.

Intrinsic Value of an Option
The value an option would have if it expired immediately.
Open Interest
The total number of contracts written on an option contract.

Open Premium
The market price of an option.

Option Writer
The investor who sells (or writes) the option and has a short position in the contract.

Out-of-the-Money Options
Call options with strike prices below the current stock price, and put options with strike prices above the current stock price.

Portfolio Insurance, Protective Put
Holding a stock (or stock index) and a put option on the same stock (or stock index). In addition to buying such a protective put, the same effect can be achieved by purchasing a bond and a call option.

Put Option
A contract that gives the owner the right, but not the obligation, to sell an asset.

Put-Call Parity
The relation of the price of a European call option in terms of the price of a European put, the underlying stock, and a zero-coupon bond: $C = P + S - PV(K) - PV(Div)$.

Straddle
A strategy that involves buying a put and a call at the same exercise price. It can be used by investors who expect the stock to be very volatile and move up or down a large amount, but who do not necessarily have a view on which direction the stock will move.

Strike (Exercise) Price
The price the contract allows the owner to buy or sell the asset thus exercising the option.

Time Value of an Option
The difference between the current option price and its intrinsic value.

Concept Check Questions and Answers

20.1.1. What is the difference between an American option and a European option?

An American option allows the holder to exercise on any date up to and including the expiration date, while a European option allows the holder to exercise only on the expiration date.
20.1.2. Does the holder of an option have to exercise it?
No, a holder of an option will exercise only when it is beneficial to the holder. If the option is out-of-the-money on the expiration date, the holder will not exercise the option.

20.1.3. Why does an investor who writes (shorts) an option have an obligation?
Because the writer of the option has the obligation to fulfill the contract and will have to buy or sell the stock to the buyer of the option in the event that it is exercised.

20.2.1. What is a straddle?
A straddle is a combination consisting of a call and a put with the same strike price and the same expiration date.

20.2.2. Explain how you can use put options to create portfolio insurance. How can you create portfolio insurance using call options?
You can create portfolio insurance by purchasing put options on a portfolio of stocks. Or you can achieve exactly the same effect by purchasing a bond and a call option.

20.3.1. Explain put-call parity.
Put-call parity relates the value of a call to the value of the stock, the bond, and the put with the same strike price and the same maturity date. It says that the price of a European call equals the price of the stock plus an otherwise identical put minus the price of a bond that matures on the exercise date of the option.

20.3.2. If a put option trades at a higher price from the value indicated by the put-call parity equation, what action should you take?
If a put trades at a higher price from the value indicated by the put-call parity, you can arbitrage by selling the overvalued put and stock and simultaneously buying the call option. You are guaranteed to make a profit while taking no risk.

20.4.1. What is the intrinsic value of an option?
The intrinsic value is the immediate exercise value. The intrinsic value of a call is the current stock price minus the strike price, while the intrinsic value of a put is the strike price minus the current stock price.

20.4.2. Can a European option with a later exercise date be worth less than an identical European option with an earlier exercise date?
Yes, a European option with a later exercise date can trade for less than an identical European option with an earlier exercise date. For example, suppose the stock price of XYZ goes to zero due to a bankruptcy. The one-month European put is worth more than the one-year European put because you can exercise and get your money sooner.

20.4.3. How does the volatility of a stock affect the value of puts and calls written on the stock?
The value of both put and call options increases with volatility of the underlying stock price.

20.5.1. Is it ever optimal to exercise an American call on a non-dividend paying stock early?
No, you should not exercise an American call on a non-dividend paying stock early. You are better off selling the call rather than exercising it.

20.5.2. When may it be optimal to exercise an American put option early?
It can be optimal to exercise a deep-in-the-money American put option.
20.5.3. When might it be optimal to exercise an American call early?

For the deep-in-the-money calls, when the present value of the dividends is larger than the interest earned.

20.6.1. Explain how equity can be viewed as a call option on the firm.

A share of stock can be thought of as a call option on the assets of the firm with strike price equal to the value of debt outstanding.

20.6.2. Explain how debt can be viewed as an option portfolio.

The debt holders can be viewed as owning the firm and having sold a call option with strike price equal to the required debt payment. If the value of the firm exceeds the required debt payment, the call will be exercised so the debt holders receive the strike price and give up the firm. If the cash flow of the firm does not exceed the required debt payment, the call is worthless, the firm declares bankruptcy, and the debt holders are entitled to the firm's assets.

Examples with Step-by-Step Solutions

Solving Problems

Problems in this chapter may involve constructing basic option intrinsic value payoff diagrams like in problem 1 below. Other problems require understanding put-call parity, like in example 2 below. You should also be familiar with factors affecting option values and basic option pricing boundaries. Finally, problems may involve understanding how corporate equity and debt securities can be viewed as a portfolio of securities including options as in example 3 below.

Examples

1. Microsoft is currently trading for $27. There are traded put and call options with a strike price of $25, and you are considering different trading strategies.

   [A] If you buy a call option with a $25 exercise price, what is the intrinsic value payoff diagram? Is the option in the money? What is the intrinsic value of a contract for 100 options?

   [B] If you buy a put option with a $25 exercise price, what is the intrinsic value payoff diagram? Is the option in the money? What is the intrinsic value of a contract for 100 options?

   [C] If you buy a straddle by buying a call option and a put option with a $25 exercise price, what is the intrinsic value payoff diagram? Is the strategy in the money? What is the intrinsic value of a contract for 100 options?
**Step 1.** Determine the payoff diagram of the call option.

The call option is in the money since the strike price is below the stock price.
The contract has an intrinsic value of $100(27 – 25) = $200.

**Step 2.** Determine the payoff diagram of the put option.

The put option is out of the money since the strike price is below the stock price.
The contract has an intrinsic value of $100(0) = $0.
Step 3. Determine the payoff diagram of the straddle.

The straddle is always in the money, unless the stock price is $25.

The contract has an intrinsic value of $200.

2. Your investment bank often deals with CEOs who want to hedge their stock options in the firm where they work. One of your clients, the CEO of a non-dividend-paying public company that has no publicly traded put options, wants to purchase a one-year European put option on his firm’s stock with a strike price of $100. Another dealer is willing to write a one-year European call option on the stock with a strike price of $100 and sell you the call option for $12 per share. The stock is trading for $109 per share, and the one-year risk-free interest rate is 3.09%. What price should you offer to sell the put option?

Step 1. Determine how to go about pricing the put option.

Since you can replicate the payoff of the put option, you can determine the cost to replicate the option using put-call parity.

Step 2. Use put-call parity and determine the strategy you must use to replicate the put option payoff.

Using put-call parity,

\[ C = P + S - PV(K) - PV(Div) \]

you can replicate the payoff of the one-year put option with a strike price of $100 as:

\[ C = P + S - PV(K) - 0 \Rightarrow P = C - S + PV(K) \]

So you must buy a call with a strike price of $100, short sell the stock, and buy a one-year zero-coupon bond with a face value of $100.

Step 3. Verify that the final payoff of the portfolio of the three securities matches the payoff of a call option.

With this combination, you have the following final payoff depending on the stock price in one year:
<table>
<thead>
<tr>
<th>Stock Price in One Year (P)</th>
<th>Above $100</th>
<th>Below $100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long the Call Option</td>
<td>$P - $100</td>
<td>0</td>
</tr>
<tr>
<td>Short the Stock</td>
<td>-P</td>
<td>-P</td>
</tr>
<tr>
<td>Long the Bond</td>
<td>$100</td>
<td>$100</td>
</tr>
<tr>
<td>Portfolio</td>
<td>$0</td>
<td>$100 - P</td>
</tr>
<tr>
<td>Sell Put Option</td>
<td>$0</td>
<td>-($100 - P)</td>
</tr>
<tr>
<td>Total Payoff</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

Therefore, you can sell the put option and have a future payoff of zero no matter what happens.

**Step 4.** Use put-call parity and solve for the price of the put such that you break even.

\[ P = C - S + PV(K) = -$12 + $110 - \frac{$100}{1.0309} = $1.00 \]

Thus, as long as you sell the put for more than $1.00, you will make a profit.

3. **Using diagrams, explain and demonstrate how corporate securities can be viewed as the following options:**

[A] Equity can be viewed as a call option on a firm.

[B] Debt can be viewed in terms of a call option on a firm.

[C] Debt can be viewed in terms of a put option on the firm.

**Step 1.** Diagram how equity can be viewed as a call option on a firm.

On the maturity date of the debt, if the value of the firm is larger than the value of the debt, \(D\), investors will pay back the debt and keep the difference for themselves. If the value of the firm is lower than the value of the debt, investors will be forced to handover the assets to lenders, and end up with a zero payoff.

**Step 2.** Diagram how debt can be viewed in terms of a call option on a firm.

Debt holders can be viewed as being long on the assets of the firm and short on a call option with a strike price equal to the value of the debt, \(D\).

If the value of the firm exceeds the required debt payment, the call will be exercised; the debt holders will therefore receive the strike price (the required debt payment) and give up the firm. If the value of the firm does not exceed the required debt payment, the call will be worthless, the firm will declare bankruptcy, and the debt holders will be entitled to the firm’s assets.
Step 3. Diagram how debt can be viewed in terms of a put option.

Debt can be viewed as a combination of being short a put option with a strike price equal to the value of debt, $D$, and long a risk-free bond with a face value equal to the value of the debt.

When the firm’s assets are worth less than the required debt payment, the put is in-the-money; the owner of the put option will therefore exercise the option and receive the difference between the required debt payment and the firm’s asset value. This leaves the portfolio holder (debt holder) with just the assets of the firm. If the firm’s value is greater than the required debt payment, the put is worthless, leaving the portfolio holder with the required debt payment.
Questions and Problems

1. You own a 1,000 call options on Apple stock with a strike price of $70 that expire in exactly one month.
   [A] If the stock is trading at $95 in one month, what is the payoff of the options?
   [B] If the stock is trading at $50 in one month, what is the payoff of the options?
   [C] Draw a payoff diagram showing the value of one call option at expiration as a function of the stock price at expiration.

2. You are undertaking a so-called strangle strategy and are long both a call and a put on the same stock with the same exercise date. The exercise price of the call is $15 and the exercise price of the put is $10.
   [A] Plot the intrinsic value of this combination as a function of the stock price on the exercise date.
   [B] What is the strategy’s maximum loss?

3. Intel stock is currently trading for $20 per share. A one-year European put option on Intel with a strike price of $15 is currently trading for $0.50. If the one-year risk-free interest rate is 5%, what is the value of a one-year European call option on Intel with a strike price of $15? (Intel pays no dividends.)

4. General Electric (GE) stock is currently trading for $50 per share. A one-year European call option with a strike price of $55 is currently trading for $8.00. GE is expected to pay dividends of $2.00 this year. If the one-year risk-free interest rate is 5%, what is the value of a one-year European put option on GE with a strike price of $55?

5. Suppose you want to insure against the possibility that the price of Apple stock will drop below $75. Describe how you can accomplish this objective using:
   [A] put options, and
   [B] a bond and a call option.

Solutions to Questions and Problems

1. [A] $1,000(95 − 70) = $5,000
   [B] $1,000(0) = $0
   [C] $
2. [A]

[B] The maximum loss is $0 based on the intrinsic values.

3. Using put-call parity:

$$C = P + S - PV(K) = 0.50 + 20 - \frac{15}{1.05} = 6.21$$

4. Using put-call parity, and assuming that dividend is paid in one year and that the risk-free rate is the correct rate to use to find the present value of the dividend:

$$C = P + S - PV(K) - PV(Div) \Rightarrow P = C - S + PV(K) + PV(Div)$$

$$= 8.00 - 55 + \frac{55}{1.05} + \frac{2.00}{1.05} = 7.29$$

5. [A] You can purchase a European put option with a strike price of $75. If Apple is above $75, you keep the stock, but if it is below $75, you exercise your put and sell it for $75. Thus, you get the upside, but are insured against a drop in the price.

[B] Instead of holding a share of Apple stock and a put, you could get the same payoff by purchasing a risk-free zero coupon bond with a face value of $75 and a European call option with a strike price of $75. In this case, if Apple is below $75, you receive the payoff from the bond. If Apple is above $75, you can exercise the call and use the payoff from the bond to buy the stock for the strike price of $75.