Introduction to Options

- The next several lectures are about “derivative” securities.
- Derivative securities have almost nothing to do with calculus.
- Their payoffs depend on the value of other securities.
- Both options and futures contracts are derivative securities.

Introduction to Options

- A call option gives its holder the right to purchase the underlying asset at a particular price called the strike price.
- A put option gives its holder the right to sell the underlying asset at a strike price.
- If you hold either a call or a put, you have a long position in the contract.
- If you sell (write) an option, you are short.

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- The Option Clearing Corporation helps to standardize contracts.
- The OCC also guarantees option payoffs.
- To guarantee payoffs, it requires that option writers post margin to cover losses.
- Margin requirements depend on what is in the writer’s portfolio.

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- Definition: If an option can only be exercised at maturity it is European.
- An American option can be exercised any time before maturity.
- When the immediate exercise of an option would result in a positive payoff, the option is called “in the money.”
- Options can be in, out of, or at the money.

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- Example: IBM call option.
- On 3/18/97, IBM closed at $139.50
- On that day, an American call option on IBM with a strike price of 140 and a maturity date of July 19th sold for $11.00
- The call gives the right to buy IBM at $140 to the holder.
- When (can) will the holder exercise?

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- Example: IBM call option.
- When will the holder profit?
- Is this option in, at or out of the money?
- The writer of the call is obligated to sell IBM if the holder exercises the option.
- When will the writer profit?
- Which is riskier, writing calls or buying them? Which has more downside risk?
Example: IBM put option.
On 3/18/97, July IBM puts with a strike $140 sold for $9.
These options give the holder the right to sell IBM at $140.
Are these puts in the money?
What does the put holder hope for?

There are many kinds of options available.
The most common options are on 100 shares of individual stocks.
Index options usually pay $100 times the difference between the level of the index and the strike price.
Foreign currency options are very popular.
Futures options and interest rate options.

We can graph the payoffs for calls and puts at expiration.
Let $X =$ strike, $S =$ stock price.
A call is worth $\max(0, S - X)$ at maturity.
A put is worth $\max(0, X - S)$ at maturity.
We visualize this with “hockey stick” diagrams.

A call’s payoff diagram:
\[ \text{Profit} = \text{exercise value} - \text{price} \]

A payoff diagram for the writer of a call:
\[ \text{Value at Expiration} \]
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A put's payoff diagram:

Value at Expiration

Profit

Price

S

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A payoff diagram for a put writer:

Payoff

S

x

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Why invest in options instead of stock?

Suppose, for simplicity, that ABC sells for $70, and an at the money call costs $7.

Think of three strategies that cost $7,000.

- buy 100 shares of ABC at $70.00 a share.
- buy 1000 calls at $7.00 a call.
- buy 100 calls and put $6,300 in T-bills at 3%.

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The three strategies have payoffs:

<table>
<thead>
<tr>
<th>Price of ABC:</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio:</td>
<td>5000</td>
<td>6000</td>
<td>7000</td>
<td>8000</td>
<td>9000</td>
</tr>
<tr>
<td>100 shares</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10k</td>
<td>20k</td>
</tr>
<tr>
<td>1000 calls</td>
<td>6489</td>
<td>6489</td>
<td>6489</td>
<td>7489</td>
<td>8489</td>
</tr>
<tr>
<td>calls + bills</td>
<td>6489</td>
<td>6489</td>
<td>6489</td>
<td>7489</td>
<td>8489</td>
</tr>
</tbody>
</table>

What type might want each payoff?

Introduction to Options

Option strategies: combine options with other securities to make particular payoffs.

- **Protective put**: buy a stock, buy a put.
- **Covered calls**: buy a stock, write a call.
- **Straddle**: buy a call and a put, same X.
- **Spread**: buy call, write call, different X, T.
- **Collar**: buy a stock, buy a put (with low X), write a call (with high X).

What is the payoff for each strategy?

We can answer with “hockey stick” diagrams for each strategy.

First we draw the diagram for each security in the strategy.

Then we add the diagrams together.
For a protective put, add a stock’s diagram:

\[
\text{Future value of a stock} = \text{future value of the stock.}
\]

Payoff diagrams are supposed to simplify the intuition behind strategies.

If you don’t like the diagrams, you can just think your way through the problem.

What are investors doing with this strategy?

Why would anyone want to follow a protective put strategy?

Covered call strategy combines long stock position with short call position.

What are investors betting on?

When does this strategy pay off?
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- Stock Payoff
- Plus payoff of written call
- Equals strategy payoff

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- The profit line:

\[ S \] Payoff
\[ x \] Value at Expiration

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- What about a straddle strategy?
- Straddles combine calls and puts with the same strike price.
- What are investors doing with straddles?
- When do straddles pay off?

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- We won't do the diagram for a spread.
- There are many different types of spread strategies.
- They consist of buying and writing options with different strike prices or maturities.
The last strategy that we will talk about is a collar strategy. A collar is a combination of a protective put and a covered call. In a collar, you buy stock, sell a call option on the stock and buy a put on the stock. Why would investors like collars?

Gives the payoff for a collar:

\[
\text{Payoff} = \begin{cases} 
0 & \text{if } S < X_p \\
S - X_p & \text{if } X_p \leq S \leq X_c \\
S - X_c & \text{if } S > X_c 
\end{cases}
\]

The profit line depends on prices.

We formalize the relationship between call and put payoffs with an arbitrage relation known as put-call parity.

You may have noticed that some of these diagrams look similar to each other.
Introduction to Options

- So that buying a call and shorting a put gives a payoff that is equal to a stock’s payoff minus the strike price.
- If there is no arbitrage in the world, then the value of a strategy that lends the PV of X, goes short a put and long a call must equal the stock price.
- P-C parity: \[ C + X/(1+r_f)^T - P = S_0 \]

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- Using put-call parity, if we know the price of a call option we can always deduce the price of a put option.
- Let’s do a numerical example to see how this works.

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- PC Parity Example: Suppose that
  - The current price of XYZ stock is $110.
  - A six-month call at X = $105 costs $17.
  - A six-month put at 105 costs $5.
  - The risk-free rate is 10.25% per year.
- Is PC parity violated in this case?
  \[ C + X/(1+r_f)^T - P = S \]
  \[ 17 + 105/(1.1025)^{.5} - 5 = 112, \text{ not } 110. \]

Introduction to Options

- PC Parity Example Continued:
  - So we know that PC is violated, how would we take advantage of the arbitrage?
  - Since the “synthetic stock” price is high, the call is overpriced compared to the put.
  - We should sell the call (+$17), buy the put (-$5), borrow the present value of X (+$100) and buy the stock (-$110).

Introduction to Options

- PC Parity Example Continued:
  - Write down payoffs as an arbitrage chart:

<table>
<thead>
<tr>
<th>Position</th>
<th>Pay now</th>
<th>S &lt; X</th>
<th>S &gt; X</th>
</tr>
</thead>
<tbody>
<tr>
<td>long stock</td>
<td>-110</td>
<td>( S_T )</td>
<td>( S_T )</td>
</tr>
<tr>
<td>short cash</td>
<td>+100</td>
<td>-105</td>
<td>-105</td>
</tr>
<tr>
<td>short call</td>
<td>+17</td>
<td>0</td>
<td>-(S_T -105)</td>
</tr>
<tr>
<td>long put</td>
<td>-5</td>
<td>(105 - S_T)</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>+2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Introduction to Options

- What if the stock paid dividends during the life of the options?
- Our “synthetic stock” would not pay the same dividends, so we need to adjust PC parity.
- The adjusted formula is:
  \[ C + X/(1+r_f)^T - P = S - \text{PV(dividends)} \]
What would we do if the “synthetic stock” costs less than the true stock?

Since PC parity is an arbitrage condition, it is rarely violated in a big way.

Many securities contain implicit options. We can use some of the option valuation techniques we will discuss to value these securities.

Examples include:
  » callable bonds
  » convertible bonds
  » warrants
  » collateralized loans

There are also lots of new types of options being developed by the street.

Examples include:
  » Asian options (average rate)
  » Barrier options (worthless if hit a barrier)
  » Lookback options (maximum, not close)
  » Binary or “bet” options.

The practice of creating new options is often called “financial engineering.”

The put-call parity relationship says that
\[ C + \frac{X}{(1+r_f)^T} - P = S - PV(\text{dividends}) \]

We can decide what to do if PC parity is violated by constructing an arbitrage chart.

Several common securities involve options.

Financial engineering is a hot field.

Summary:

Popular options strategies include
  » protective puts,
  » covered calls,
  » straddles,
  » spreads,
  » and collars.

We can make a payoff diagram for each.