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.

Introduction to Options

- 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.

Introduction to Options

- 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.

Introduction to Options

- 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?

Introduction to Options

- 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?

Introduction to Options

- 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?
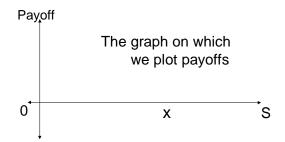- What does the put holder hope for?

Introduction to Options

- 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.
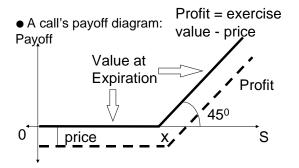- Futures options and interest rate options.
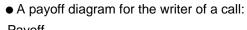
Introduction to Options

- 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.
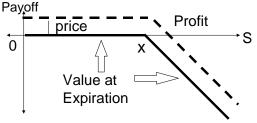- We visualize this with "hockey stick" diagrams.

Introduction to Options

Payoff

The graph on which we plot payoffs

0   X   S

Introduction to Options

- A call's payoff diagram:

Payoff

Profit = exercise value - price

Value at Expiration

Profit

45^0

0   price   X   S

Introduction to Options

- A payoff diagram for the writer of a call:

Payoff

price   Profit

0   X   S

Value at Expiration

Introduction to Options

- A put's payoff diagram:

Payoff

x

Value at Expiration

x

0

Profit

price

S

Introduction to Options

- A payoff diagram for a put writer:

Payoff

0

x

S

x
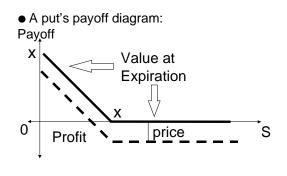
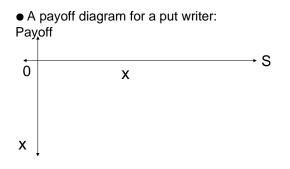## Introduction to Options

- 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%.

Introduction to Options
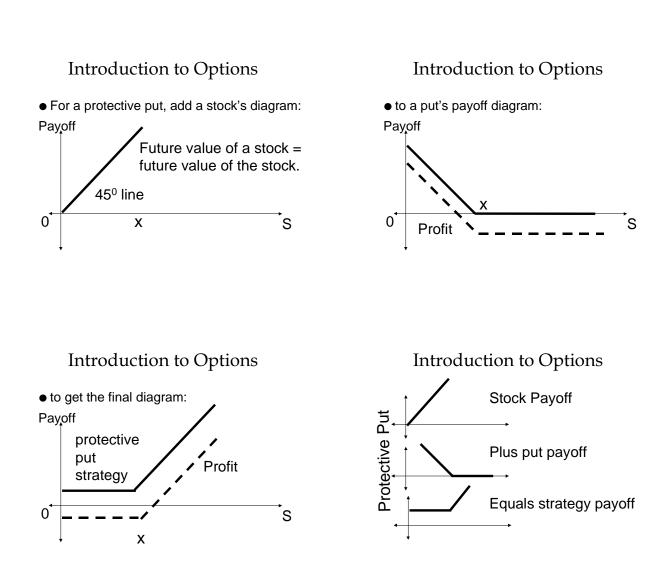
- The three strategies have payoffs:

	Price of ABC:				
Portfolio:	50	60	70	80	90
100 shares	5000	6000	7000	8000	9000
1000 calls	0	0	0	10k	20k
calls + bills	6489	6489	6489	7489	8489

- What type might want each payoff?

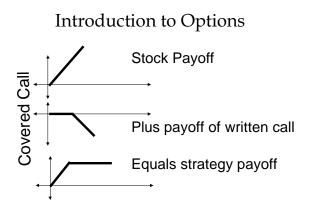## Introduction to Options

- Option strategies: combine options with other securities to make particular payoffs.
- <u>Protective put</u>: buy a stock, buy a put.
- <u>Covered calls</u>: buy a stock, write a call.
- <u>Straddle</u>: buy a call and a put, same X.
- <u>Spread</u>: buy call, write call, different X, T.
- <u>Collar</u>: buy a stock, buy a put (with low X), write a call (with high X).
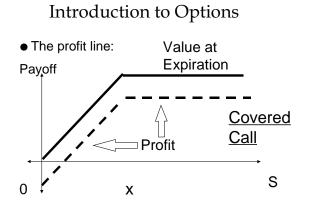
Introduction to Options

- 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.

Introduction to Options

● For a protective put, add a stock's diagram:

Payoff

Future value of a stock = future value of the stock.

45^0 line

0   x   S

Introduction to Options

● to a put's payoff diagram:

Payoff

x

0

Profit

S

Introduction to Options

● to get the final diagram:

Payoff

protective put strategy

Profit

0

x

S

Introduction to Options

Stock Payoff

Protective Put

Plus put payoff

Equals strategy payoff

Introduction to Options

● 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?

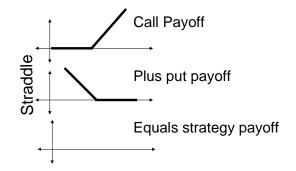● Why would anyone want to follow a protective put strategy?

Introduction to Options

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

● What are investors betting on?

● When does this strategy pay off?

Introduction to Options

Covered Call

Stock Payoff

Plus payoff of written call

Equals strategy payoff

Introduction to Options

- The profit line:

Payoff

Value at Expiration

Covered Call

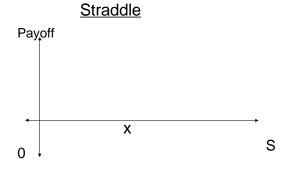Profit

0

x

S

Introduction to Options

- 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?

Introduction to Options

Straddle

Call Payoff

Plus put payoff

Equals strategy payoff
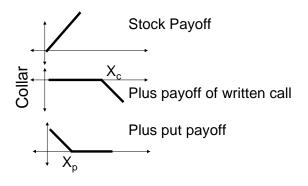
Introduction to Options

Straddle

Payoff

x

S

0

Introduction to Options

- 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.
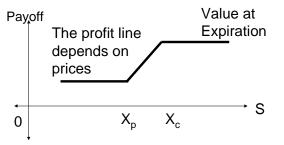
Introduction to Options

- 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.
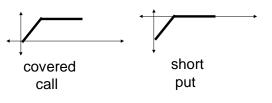- Why would investors like collars?

Introduction to Options

Stock Payoff

X_c

Plus payoff of written call

Plus put payoff

X_p

(y-axis label: Collar)

Introduction to Options

- Gives the payoff for a collar:

Payoff

The profit line depends on prices

Value at Expiration

X_p X_c

0

S
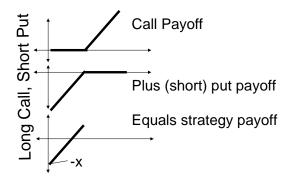
Introduction to Options

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

covered call

short put

Introduction to Options

- We formalize the relationship between call and put payoffs with an arbitrage relation known as put-call parity.
- Suppose that you bought a call and wrote a put with the same maturity and strike price.
- The payoff to this strategy would be

Introduction to Options

Call Payoff

Plus (short) put payoff

Equals strategy payoff

-x

(y-axis label: Long Call, Short Put)

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: $C + X/(1+r_f)^T - P = S_0$

Introduction to Options

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

Introduction to Options

- 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?

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

  $17 + 105/(1.1025)^{(.5)} - 5 = 112$, 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:

Position	Pay now	S < X	S > X
long stock	-110	S_T	S_T
short cash	+100	-105	-105
short call	+17	0	$-(S_T - 105)$
long put	-5	$(105 - S_T)$	0
Total:	+2	0	0

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:

  $C + X/(1+r_f)^T - P = S - PV(dividends)$

Introduction to Options

- 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.

Introduction to Options

- 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

Introduction to Options

- 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."

Introduction to Options

Summary:
- Calls give the right to buy, puts to sell.
- American options can be exercised before T, European can't.
- There are lots of types of options.
- We can summarize option payoffs with diagrams.

Introduction to Options

Summary:
- Popular options strategies include
  » protective puts,
  » covered calls,
  » straddles,
  » spreads,
  » and collars.
- We can make a payoff diagram for each.

Introduction to Options

Summary:
- The put-call parity relationship says that
  $C + X/(1+r_f)^T - P = S - PV(dividends)$
- 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.