Lecture 20
Options and Futures

Readings
- BM, chapter 20
- Reader, Lecture 20
A derivative is any security whose payoff derives from the value of another asset or security. For example,

- **Futures Contract**: Agreement to buy or sell a fixed quantity of a commodity, financial asset etc. at a set price on a fixed date. Trades are made on organized futures exchanges.

- **Forward Contract**: Identical in spirit to a futures contract, but trade is made directly with “counterparty” (such as a bank).

- **American Option**: The right to buy (call option) or sell (put option) an underlying asset at a specified price (the strike price or exercise price) on or before the expiration date.

- **European Option**: Same as an American except that it may only be exercised on the expiration date.
Derivative securities are often considered very “risky”.
  – For example, a call option on a stock has a higher beta than the underlying stock.
  – Risk, however, can be good or bad, depending on application.

Hedging: Derivative is used to offset risk of existing position, leading to lower net risk.

Speculating: Derivative is used to increase risk, so that large gains are achieved when market moves “right” way.
  – Large loss occurs in opposite case.
In January 1995, Nick Leeson had losses of $320 million.
- He had made huge bets on the direction of movements in the Nikkei index using futures contracts.
- No oversight or controls to prevent this.
- Nobody even knew (he’d set up dummy accounts to hide losses)
- Bonuses based on performance, with no penalty for poor performance.

He used “straddles” to bet Nikkei wouldn’t move much.
- Leeson’s losses were $1.3 billion by Feb. 23.
- No more bank.
In Nov. 1994, WSJ printed a long article about how municipalities (inc. Orange County) were “lowering their borrowing costs” by using derivatives.

- Robert Citron (Orange County treasurer) had invested in a lot of “inverse floaters”.
  » Payments rise as interest rates fall.
- Interest rates rose…
- Investment pool lost $1.64 billion in December 1994.
- Much of this was recovered in settlements with financial institutions (esp. Merrill Lynch). Arguments included:
  » Investors were “unsophisticated”.
  » Risks were not adequately disclosed.
  » Investments violated California constitution.
Derivatives and Risk: Lessons from big losses

- Anything that looks like a free lunch ("borrowing costs are low as long as rates fall…") almost certainly has a catch.

- Derivatives make it very easy to take big risks, which may not be well understood.
  - Trading in derivatives needs to be accompanied by adequate monitoring and control.
  - Complex derivatives need to be well explained to unsophisticated investors.
    » Need separate application to trade options at Schwab or E-Trade.

- Key point: (Almost) anything we can do with a derivative we can also do with the underlying asset directly.
  - This fact allows us to price derivatives relative to underlying asset.
  - Derivatives just make it easier to make large changes in risk exposure than trading in huge quantities of the underlying asset.
A farmer plants corn today, to sell in 9 months.

Without hedge, profits depend on market price 9 month later, for good or bad. Or…

**Solution 1**: The farmer sells *corn futures* today, in order to *hedge market price risk*:

- This commits the farmer to sell a certain amount of corn in the future, but at a price determined today.
- Actual market price 9 months later then does not affect profits.
Hedging with **Options**: Farmer Example

**Solution 2**: The farmer buys a **put option** on corn, with an exercise price equal to the minimum acceptable price for the crop.
- This provides farmer the option to sell at this price.
- The put option is thus an insurance policy that guarantees a floor below which the price will never fall.
- If actual market price turns out to be higher, then let option expire unused.

The amount paid for the option – called the **option premium** – is the insurance premium.
Options: Other Examples

- Holders of **convertible preferred stock** and **bonds** have the option to convert their securities into common stock.
- **Warrants** are sometimes issued with other securities.
  - Warrants give the holder the right to buy a specified number of shares at a specified price.
- Many companies offer some compensation in the form of **employee stock options**.
- Most corporate bonds are **callable**
  - Issuing firm can “call” its debt by paying strike price (usually slightly above the par value).
- Mortgage loans usually have a **refinancing option**
  - Borrower can pay off existing loan with proceeds of new loan.
- Common stock = call option on assets of firm.
Option Terminology

- **Strike Price**: the price at which the option holder can purchase the stock (or other underlying asset).
- **Expiration Date**: the final date at which the option can be used.
- **Exercising an Option**: to use the option to purchase stock.
- **Four option positions**:
  - Call option buyer or seller
  - Put option buyer or seller
- For lots of information on options, see CBOE Web page, [http://www.cboe.com/education](http://www.cboe.com/education).
Call option allows stock purchase at $100. Buyer pays premium to enjoy positive payoffs.
Put Buyer Payoff At Expiration Date, Strike Price = 100

Put option allows stock sale at $100.
Buyer pays premium to enjoy positive payoffs

Future Stock Price

$ Payoff

0 50 100 150 200

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Call Seller Payoff At Expiration Date, Strike Price = 100

Call option allows stock sale at $100.
Seller earns premium to offset negative payoffs

Future Stock Price

$ Payoff

0  50  100  150  200

- 50

- 100

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Put option allows stock sale at $100.
Seller earns premium to offset negative payoffs
These payoffs can be written in the form:

- **Call**: \( C^* = \text{Max} \ [0, S^* - K] \)
- **Put**: \( P^* = \text{Max} \ [0, K - S^*] \)

where \( S^* = \) underlying asset price at expiration
\( K = \) exercise price
The current market price of a stock is $100. You hold an expiring option. Should you exercise it, if…

- It is a call option with exercise price $90?
  - Answer: Always exercise “in the money” option at expiration.
  - What is the option’s payoff?
- It is a put option, with exercise price also $90?
  - Answer: Never exercise “out of the money” option at expiration.
- It is a call option, with exercise price $120?
  - Answer: Never exercise “out of the money” option at expiration.
- It is a put option, with exercise price of $120.
  - Answer: Always exercise “in the money” option at expiration.
Suppose a stock pays no dividends, and that the riskless interest rate is $r$.

What are the payoffs in one year from the following investment strategy:
- Buy one share.
- Buy a European put option with exercise price $K$.
- Borrow the present value of $K$. 

Relationship between Put and Call Values
## Payoffs from Portfolio

<table>
<thead>
<tr>
<th>Present Date</th>
<th>Expiration Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S^* &lt; K$</td>
</tr>
<tr>
<td>Buy stock</td>
<td>- $S$</td>
</tr>
<tr>
<td>Buy Put</td>
<td>- $P$</td>
</tr>
<tr>
<td>Borrow</td>
<td>$K/(1+r)$</td>
</tr>
<tr>
<td>Total</td>
<td>- $S - P + K/(1+r)$</td>
</tr>
</tbody>
</table>

- What does this payoff look like?
Payoff to Portfolio on Expiration Date ($K = 100$)

- **Put option**
- **Stock**
- **Portfolio**

Future Stock Price vs. $\$ Payoff$

- $K = $100
The payoff of the portfolio is identical to that of a European call option.

The price of the call option must therefore equal the total cost of the portfolio, i.e.

\[ C = S + P - K / (1+r)^T \]

This is called **Put-Call parity**.
Early Exercise

- Put-call parity gives us an important result about exercising American call options.

\[ C = S + P - K/(1+r)^T \]
\[ \geq S - K/(1+r)^T \]
\[ > S - K. \]

- In words, the value of a European (and hence American) call is strictly larger than the payoff of exercising it today.