Derivatives 1: Futures and Options

FNCE102 R. Loh: Week 11

March 2016

See Chapter 10 and additional class notes.

Outline of derivative lectures

- **Part 1: Futures and options**
  - Futures versus forwards
  - Pricing futures contracts
  - Margin requirements of futures
  - Call and put options
  - Option profit profiles
  - Determinants of option value
- **Part 2: Hedging & Interest rate derivatives**
  - Hedging with derivatives
  - Forward rate agreements (FRAs)
  - Interest rate swaps

Derivatives

- Securities whose value is derived from the value of some underlying asset or financial instrument
- Underlying asset can be a stock, T-bill/bond, foreign currency, commodity or even another derivative security
- Derivative security prices are related to factors affecting prices in the spot market for the underlying asset
- Types of derivatives
  - Forwards
  - Futures
  - Options
  - Swaps

Purpose of trading derivatives

- To Speculate
  - Take a position with the goal of profiting from expected changes in the contract's price.
  - No position in underlying asset.
- To Hedge
  - Minimize or manage risks
  - Have position in spot market with the goal to offset risk
- Note that a derivative contract is a "zero sum game". How much you gain in a contract is equivalent to how much your counter party lost.

Forward Contracts

- Agreement to buy or sell a specified quantity of an asset at a specified price, with the delivery at a specified time and place
- Party that agrees to buy has a long position
- Party that agrees to sell has a short position

Features of Forwards

1. Typically settled with cash and delivery of physicals at maturity.
   - Although there are some non-deliverable forwards (NDFs), e.g. non-traded currencies.
2. Contract size negotiable.
3. Transacted OTC (over the counter), not on an exchange. Therefore subject to counter-party risk.

Futures

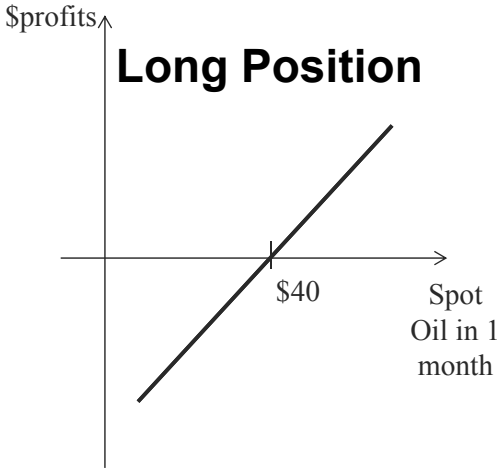
- Agreement to buy or sell a specified quantity of an asset at a specified price, with the delivery at a specified time and place or cash settlement at maturity.

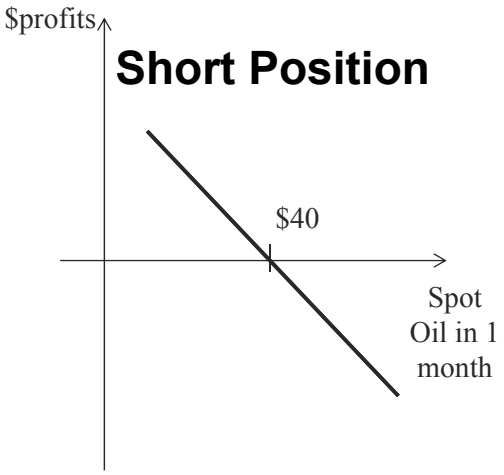
Futures are different from forwards in that…

1. Delivery may not take place. Instead position is cash settled at maturity or reversed before maturity. http://www.cmegroup.com/trading/energy-metals/index.html
2. Position is marked to market every trading day.
3. Contract specifications are standardized.
4. Transacted on an exchange with guaranteed settlement.

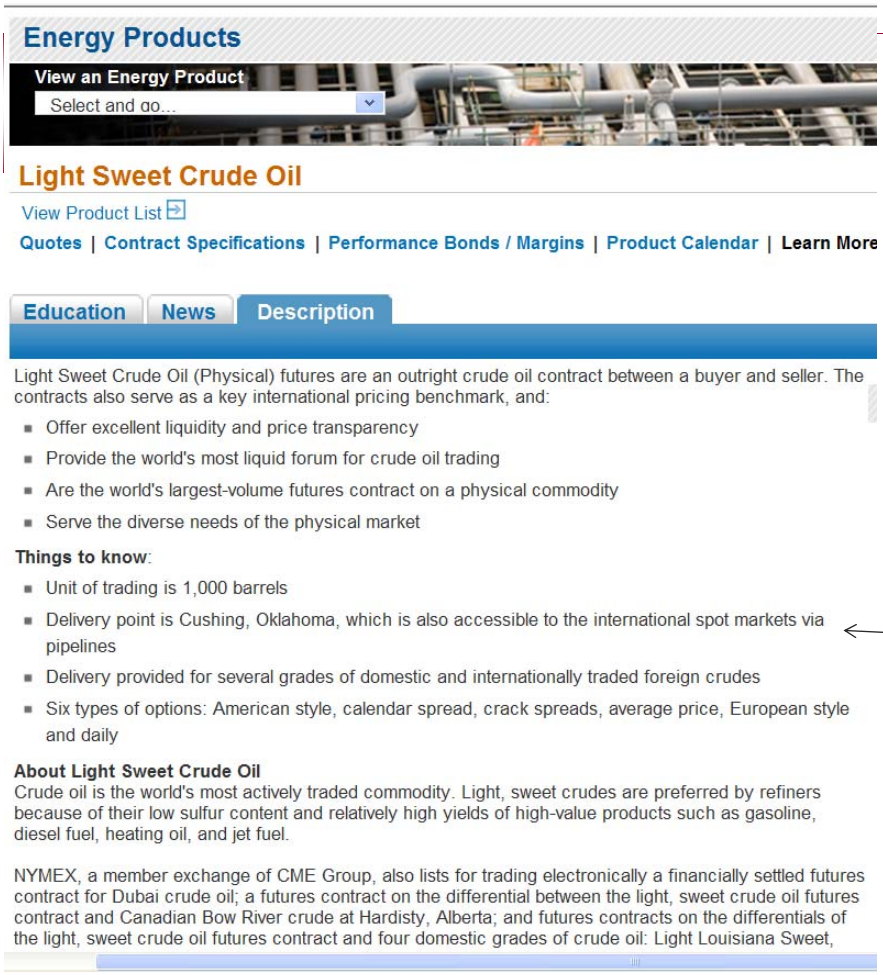
Futures/Forward profit at maturity

- Maturity profit profile on a 1-month crude oil futures contract at a futures price of $40.





Important! You must know how to plot maturity profits of a derivative contract, where the horizontal axis is the spot price of the underlying asset at maturity.



Eg of physically settled contract

http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude_learn_more.html

http://www.cmegroup.com/trading/energy/crude-oil/emini-crude-oil_contract_specifications.html

Eg of cash-settled contract

E-mini Crude Oil Futures

Code	QM	
Venue	CME Globex, Open Outcry (New York)	
Hours (All Times are New York Time/ET)	CME Globex:	Sunday – Friday 6:00 p.m. – 5:15 p.m. (5:00 p.m. – 4:15 p.m. Chicago Time/CT) with a 45-minute break each day beginning at 5:15 p.m. (4:15 p.m. CT)
	Open Outcry:	Monday – Friday 9:00 AM to 2:30 PM (8:00 AM to 1:30 PM CT)
Contract Unit	500 barrels.	
Pricing Quotation	U.S. dollars and cents per barrel.	
Minimum Fluctuation	$0.025 per barrel	
Floating Price	The Floating Price for each contract month will be equal to the NYMEX Light Sweet Crude Oil Futures contract final settlement price for the corresponding contract month on the last trading day for that contract month.	
Termination of Trading	Trading in the current delivery month shall cease on the business day immediately preceding to the last day of trading in the current delivery month of the NYMEX Light Sweet Crude Oil futures contract.	
Listed Contracts	Current year and 5 calendar years	
Position Limits	NYMEX Position Limits	
Rulebook Chapter	NYMEX Rulebook Chapter 401	
Settlement Type	Financial	
Exchange Rule	These contracts are listed with, and subject to, the rules and regulations of NYMEX.	

Overview | **Forwards, Futures** | Options

Marked-to-market feature of futures

Exchange: NYM
Asset Class: CRUDE OIL
Product: CL - CRUDE OIL FUTURE NYME

http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude_performance_bonds.html

Exchange	Asset Class	Product	Product Code	Start Period	End Period	Maintenance
NYM	CRUDE OIL	CRUDE OIL FUTURE NYMEX	CL	02/2016	04/2016	3,500 USD

Speculative ("Spec") /non-member initial margin requirements for all products are set at 110% of the maintenance margin requirement for a given product.

- An **initial margin** (known as "performance bond" in CME) is needed to initiate one contract.CME's initial margin for a non-member is 110% of the maintenance margin.
  - Hence, initial margin here =
- Any gains or losses on the contract value will be reflected on the margin account (marked to market). When the margin account drops below the **maintenance margin**, a margin call will require the investor to top up to the initial margin.
- Margin requirements change according to the level and the volatility of the Spot.
- See example in notes: MSCI SG free index.

Valuation of Financial Futures

- The futures price is always linked to the spot price of the underlying asset. However, the impact of opportunity costs or benefits of owning the futures instead of the asset causes the futures price to be different from the spot price
- Example of such costs and benefits of futures
  - + Carrying costs (e.g. storage costs $c\%$)
  - + Opportunity costs of money (interest rate $r\%$)
  - – Dividend yield ($d\%$)
  - – Convenience costs ($v\%$)
- Futures>Spot is called contango (usually true for commodities)
- Futures<Spot is called backwardation.

Parity Condition for Futures Price

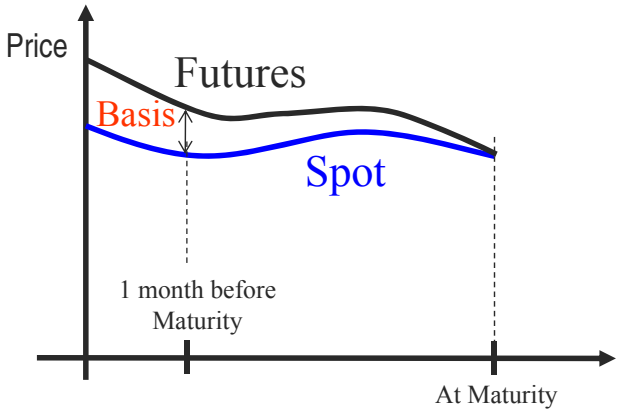
- E.g. A 30-day single stock futures price is affected by interest rate and dividend yield. No carrying cost or convenience yield.
  - Interest rate effect implies that futures price should be higher than the spot. By not buying the underlying asset, we don't need to fork out cash, hence this cash on hand can earn interest (*r*). Since one is better off holding the futures, one should pay more for the futures.
  - Dividend yield effect implies that futures price should be lower than the spot. By buying the derivative, we are not entitled any dividends (*d*) that are paid out by the underlying asset. Since one is worse off with the futures, one should only pay a lower price for the futures.
  - Overall we get $F = S(1 + r - d)$.
- Hence the general formula is:

$$F = S(1 + r + c - d - v)$$

Where *r*, *d*, *c*, and *v* are in percent after applying the relevant interest accrual basis.

Basis

- Difference between the futures and spot price is called the “basis”.
- The futures price will converge towards the spot price at maturity because F will eventually=S because as maturity approaches, $(1 + r + c - d - v)$ becomes closer and closer to 1.
- E.g. suppose futures > spot (contango) one month before maturity. As maturity approaches, the futures price will converge to the spot price.



Arbitrage with Futures

- Investors can capitalize on differences when the actual price of futures is different from its theoretical implied futures price according to the futures parity condition.
- Example. If gold costs 2% p.a. to store and interest rate is 1% p.a. and the current spot price is $1400/ounce. What should the one-year futures price be?
  - Futures price should be F=1400×(1+0.02+0.01)=$1442.
  - If the actual futures price is too high, e.g., $1450. We should borrow money, buy spot gold (store for 1 year), and enter into a futures contract maturing in 1 year to sell gold for $1450.

Are you long or short the underlying asset?

- Futures/Forwards can be used for hedging.
- To hedge: Take the opposite position as your underlying spot position in a futures/forward contract.
- But do you have an underlying long or short on the spot?
- A general rule to check if you are long or short "something" (e.g., foreign currency, stock, real estate, or a commodity).

LONG: You are happy if the price of that "something" goes _____.
SHORT: You are happy if the price of that "something" goes _____.

- This rule is particularly useful for natural underlying positions arising from business or expected future actions.
  - If you own a car, are you short or long oil?
  - If you are going to buy an apartment in SG next year, are you long or short SG real estate now?
  - If your business buys clothing from Korea every month, are you long or short the Korean Won?
  - A farmer who grows wheat is long or short wheat?

Risks of Trading Futures

- Market risk
  - Speculators win or lose based on the changing market prices.
  - Hedgers have a position in the underlying asset, and won't be impacted by contract price volatility, unless they do not have enough cash for margin calls before expiration.
- Basis risk
  - Basis risk is the risk of imperfect correlation between the % changes in the futures contract price and the % changes in the spot price over the hedging period.
- Liquidity risk
  - If a contract is not widely-traded, it is difficult to find a counterparty to close a position before maturity.
- Credit risk/Counterparty risk
  - Counterparty defaults in futures is mitigated by daily marked-to-market accounting.
  - Forwards have much larger counter-party risk: If the other party in the forward contract defaults, you can suffer large losses.

Options

Week 12 (continued)

Call and put options
Option profit profiles
How to price options?

Options

- The buyer of an option pays a premium to the seller/writer for the right but not the obligation to buy or sell the underlying asset at a stated strike price within a specific period of time.
  - Call option: Right to buy
  - Put option: Right to sell
- The premium paid to the writer is the cost or price of the option.
- Options are unlike futures and forwards in that:
  - You have to pay a premium to buy the option (not free).
  - A buyer of a futures/forward contract has the obligation to make delivery/settlement at maturity. But an option buyer can “walk away” if exercising is not profitable. By not exercising, the option buyer lose only the option premium.

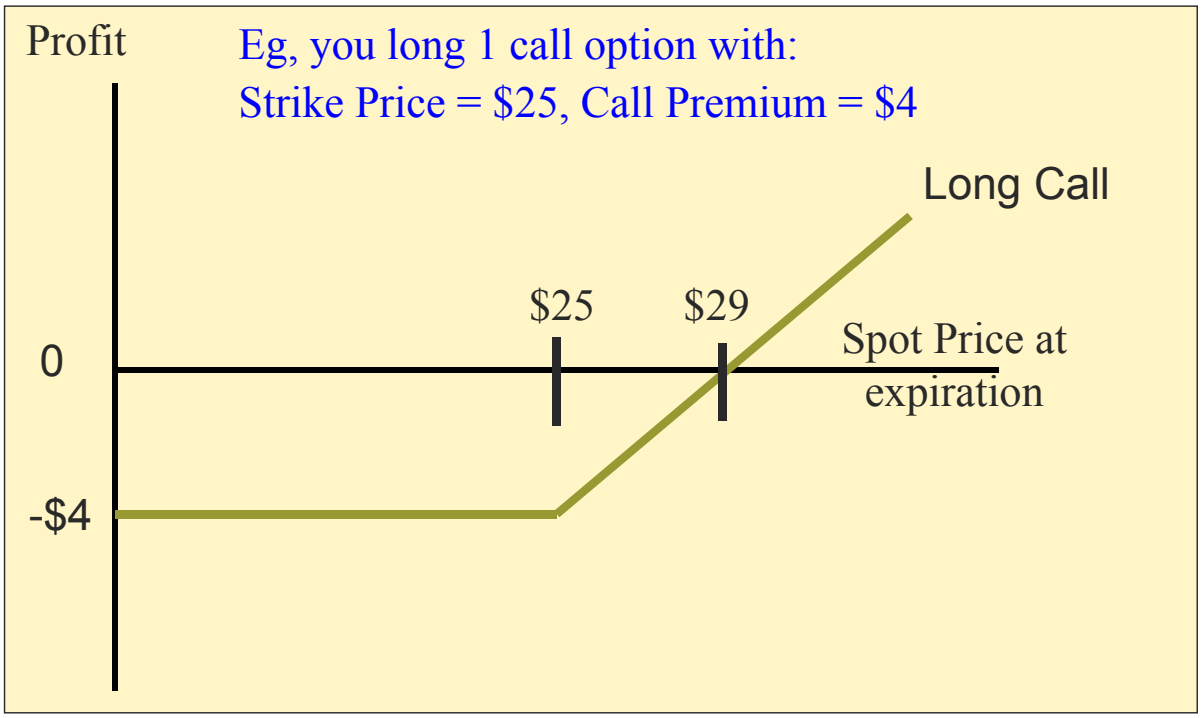
Calls and Puts

- A call (put) option gives the right but not the obligation to buy (sell) the underlying asset at a set "strike" price for a specified period of time.
- Seller or writer of the option
  - Receives the premium up front
  - Seller has an ongoing obligation to sell (call) or buy (put) if the buyer decides to exercise the option contract
- European style options can only be exercised at maturity. American options can be exercised anytime
  - Equity options are American style
- If the asset's spot price is equal to the strike price of the option, we say that the option is "at the money".
  - Calls: Spot>Strike, means in the money. Spot<Strike, out of the money
  - Puts: Spot<Strike, means in the money. Spot>Strike, out of the money

Speculating with Call Options

- BUY A CALL: Speculator thinks the spot price will appreciate above a particular strike price K and pays a premium for the right but not the obligation to buy the spot asset at strike price K.
- If the spot price appreciates above K, the option contract is in-the-money and buyer of the call would exercise.
- If the spot price does not appreciate beyond K, option is out-of-the-money, and buyer of the call does not exercise. Loses the premium paid for the option.
- If exercised at maturity, net profit equals
  - – Amount paid for the spot (call's strike)
  - + Price received for selling spot (spot price at maturity)
  - – Amount of the premium
- If not exercised, net profit at maturity equals
  - – Amount of the premium

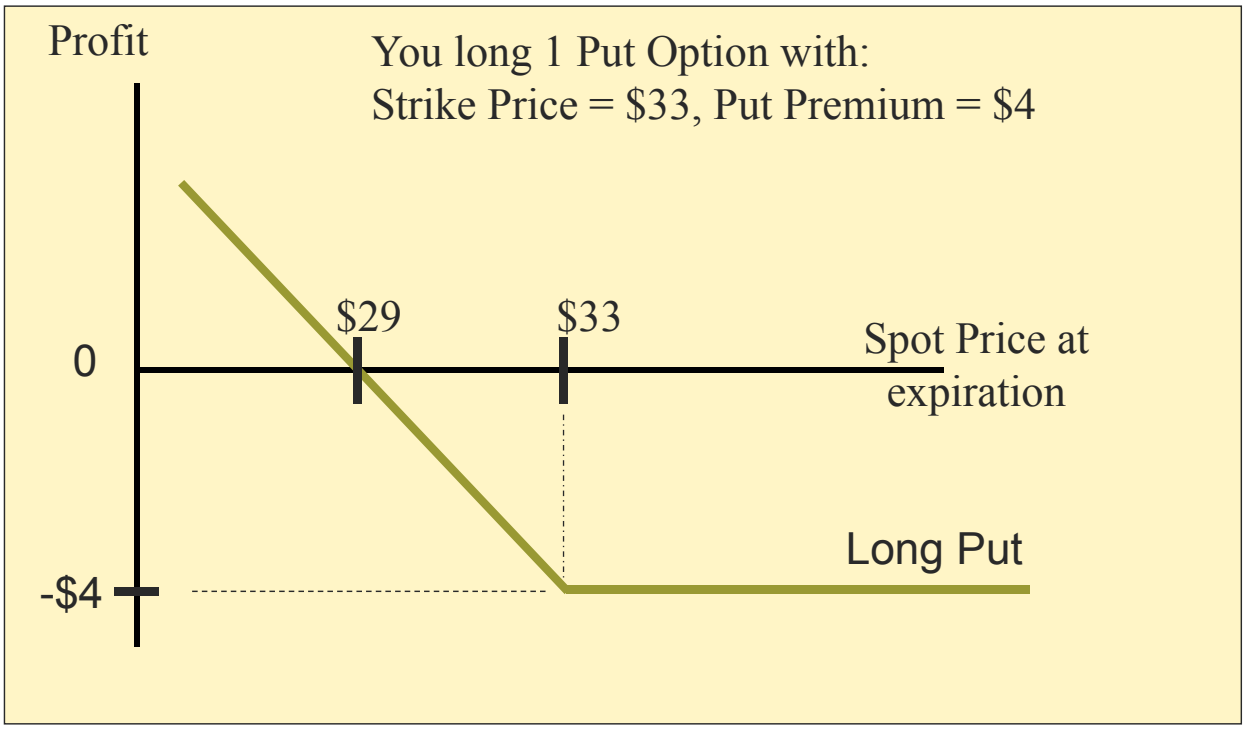
Speculating with Call Options



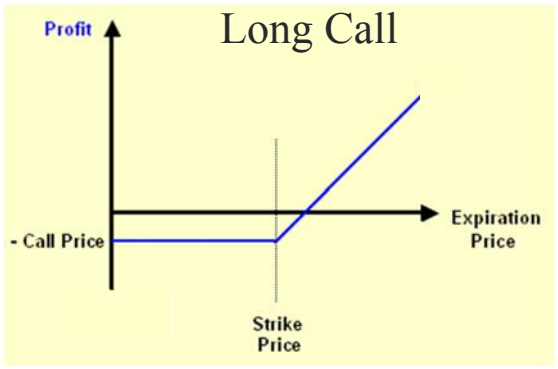
Speculating with Put Options

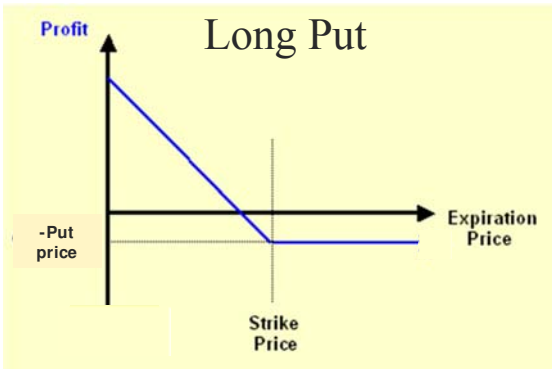
- BUY A PUT: Speculator thinks a spot price will depreciate below a particular strike price K and pays a premium for the right but not the obligation to sell the spot asset at the strike price K.
- If the spot price depreciates below the strike price the option contract is in-the-money and buyer of the put would exercise.
- If the spot price does not depreciate below the strike price, option is out of the money, and buyer of the put does not exercise. Loses the premium paid for the option.
- If exercised at maturity, net profit equals
  - – Amount paid to buy spot (Spot price at maturity)
  - + Price received for selling spot (put's strike)
  - – Amount of the premium
- If not exercised, net profit at maturity equals
  - – Amount of the premium

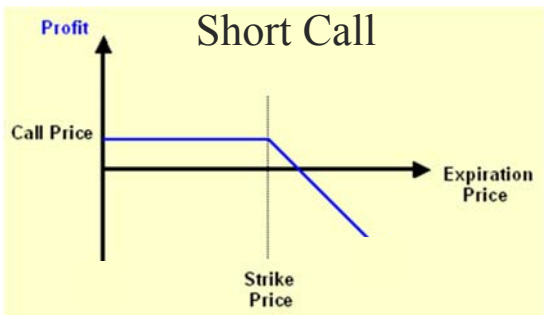
Speculating with Put Options

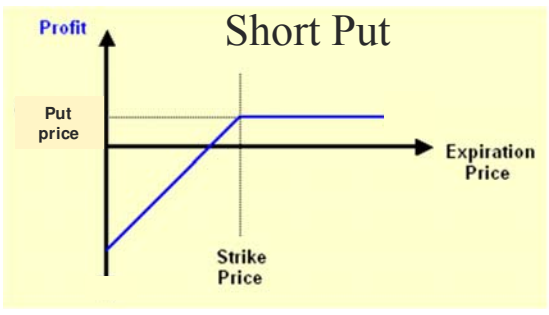


Option profit profiles









Stock Option Quotations

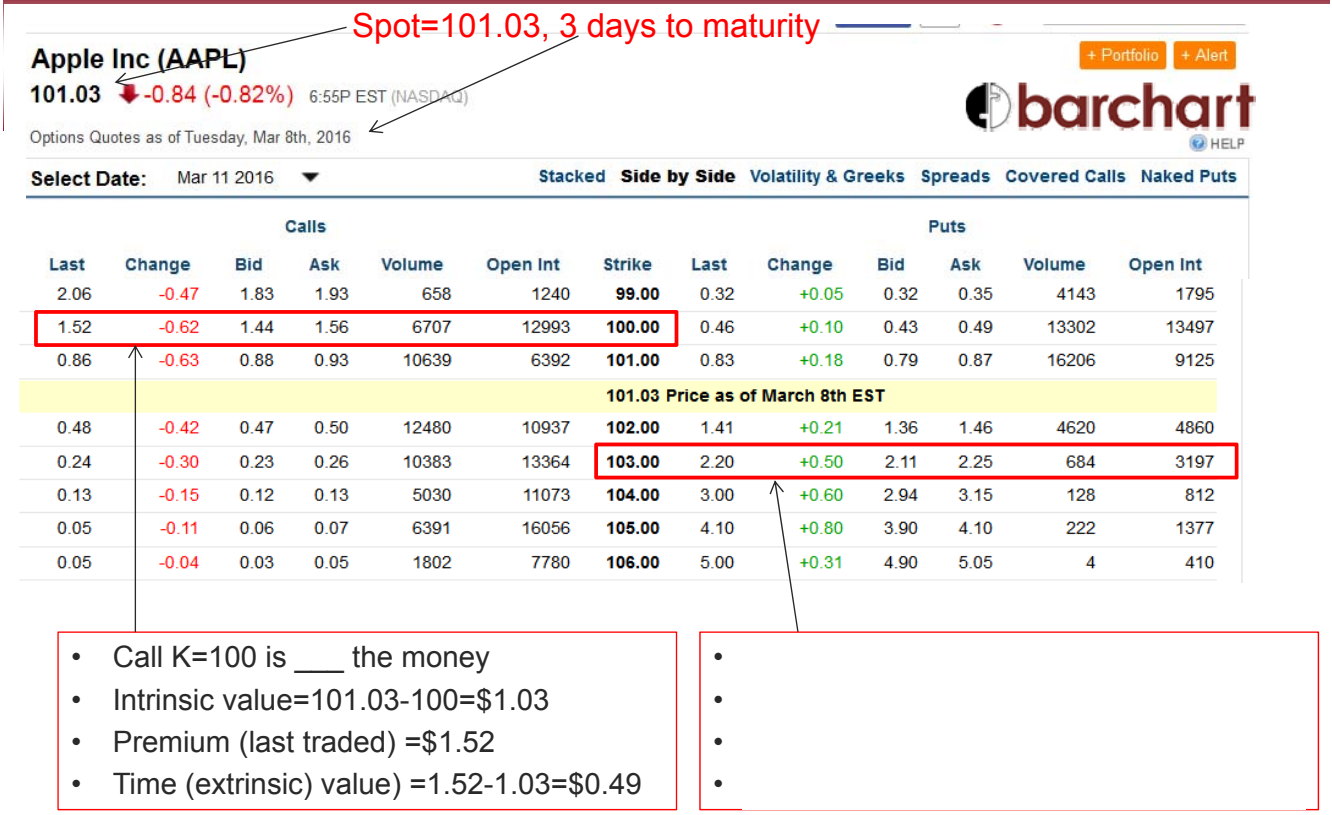
- Options quotations available in the financial press and on the Internet
  - Option contracts guaranteed by a clearinghouse to make sure sellers or writers fulfill their obligations.
  - Option writing requires margin
- Multiple option contracts for a company's stock
  - Different strike prices and expiration dates
  - Quotes indicate the volume, premium, strike price, maturity, and open interest
    - Open interest is the number of contracts that have been opened but have yet to be closed.
    - Volume usually concentrates around "at the money" options.
  - Refer to AAPL example from barchart.com

Intrinsic and extrinsic value of option premium

- Option premium has an intrinsic and extrinsic component.
- Extrinsic component is also called the "time value".
- Intrinsic component is determined by whether the option is in, out, or at-the-money
  - For Calls, intrinsic value = Max {0, S-K}
  - For Puts, intrinsic value = Max {0, K-S}

  where K = Strike price, S = spot price at maturity
- Extrinsic value depends on characteristics such as volatility, time left to maturity, dividend yield, interest rate.

Illustrating intrinsic and extrinsic value



- Call K=100 is ___ the money
- Intrinsic value=101.03-100=$1.03
- Premium (last traded) =$1.52
- Time (extrinsic) value) =1.52-1.03=$0.49

-
-
-
-

Option pricing formula

- Black and Scholes (1973) European call option pricing formula: $C = N(d_1)S - N(d_2)Ke^{-rt}$,
  where $d_1 = \frac{1}{\sigma\sqrt{t}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t\right]$, and $d_2 = d_1 - \sigma\sqrt{t}$.
  - where *N*(.) is the cumulative distribution function of the standard normal distribution.
  - *t* is the time to maturity in years.
  - *S* is the current spot price of the underlying asset.
  - *K* is the strike price.
  - *r* is the risk free rate (p.a., expressed in continuous compounding).
  - σ is the annual expected volatility of returns of the underlying asset.
- And the value of a put is determined by put-call parity, which is $C - P = S - \mathrm{PV}(K)$.
- Formulas will be more complicated for American options, and for assets with dividends. I won't test these formulas in an exam but you need to understand intuition on key inputs (slide 31) and how to interpret the entering of such inputs into any online option value calculator (next slide).

Options Calculator

www.cboe.com/tradtool/IVolFree.aspx?ServiceId=7

Powered by IVolatility.com

The IVolatility.com Options Calculator is an educational tool intended to assist individuals in learning how options work. It is not intended to provide investment advice, and users of the Options Calculator should not make investment decisions based upon values generated by it.

Symbol: [ ] Stock or Index Symbol Option symbol Go!

Today's date: 03/11/2016 ? Calculators Help ? FAQ

Style:	American
Price:	101.03
Strike:	100
Expiration Date:	FLEX
Days to Expiration:	3
Volatility %:	25
Interest Rate%:	0.438
Dividends Date (mm/dd/yy):	
Dividends Amount:	
Dividends Frequency:	Monthly

Calculate

	Call	Put
Symbol:	N/A	N/A
Option Value:	1.5176	0.4850
Delta:	0.6791	-0.3209
Gamma:	0.1564	0.1569
Theta:	-0.1375	-0.1367
Vega:	0.0328	0.0329
Rho:	0.0055	-0.0025

Implied Volatility

	Option Price	Vola %
Call	1.52	25.07

Calculate

Just google for Black and Scholes option pricing calculator and enter AAPL call e.g.:

- Call with K=100, S=101.03, American Option.
- Assume relevant R_f rate, e.g. 0.438% (automatically provided by CBOE here).
- Time to maturity=3 days
- Volatility of the asset, can be proxied by past volatility (see next slide, about 25% p.a.). Assume no dividends.
- Call Price = $1.5176, similar to $1.52 actual traded value in slide 27.

www.barchart.com/technicals/stocks/AAF barchart.com aap

Apple Inc (AAPL)

101.17 +0.05 (+0.05%) 4:09P EST (NASDAQ)

Technical Analysis as of Thu, Mar 10th, 2016

Technical Analysis Summary **Daily Quotes** Weel

Period	Moving Average	Price Change	Percent Change
5-Day	101.64	-0.33	-0.33%
20-Day	98.19	+6.90	+7.32%
50-Day	98.35	-5.65	-5.29%
100-Day	106.91	-10.69	-9.56%
200-Day	113.12	-28.45	-21.95%
Year to Date	97.79	-4.09	-3.89%

Period	Raw Stochastic	Stochastic %K	Stochastic %D
9-Day	63.66%	64.99%	72.35%
14-Day	75.26%	74.66%	78.16%
20-Day	76.88%	76.31%	79.59%
50-Day	51.53%	51.15%	53.30%
100-Day	27.94%	27.73%	28.90%

Period	Relative Strength	Percent R	Historic Volatility
9-Day	61.57%	36.34%	22.03%
14-Day	57.46%	24.74%	21.78%
20-Day	53.53%	23.12%	22.46%
50-Day	47.59%	48.47%	32.52%
100-Day	47.25%	72.06%	29.37%

If you average these numbers: Volatility of AAPL is about 25% p.a.

Impact of different factors on option premium

	Factor influencing option premium	Call	Put
obvious	S: Current price of underlying	+	–
obvious	K: Strike price	–	+
Explained below	Yield from holding underlying asset (div)	–	+
Explained below	t: Time to maturity	+	+
Explained below	σ: Price volatility of underlying asset	+	+
Explained below	r: Interest rate	+	–

- The greater the maturity or volatility, the greater the chance of the asset getting in-the-money.
- The greater the interest rate, the more valuable the call. Since you don't need to cough out cash to buy the spot, you can invest the money in the high interest rate. A put is the opposite: If I have the right to sell at say $100 in the future and interest rates are high, the PV of the $100 is lower.
- If underlying asset has a dividend, then holding a call doesn't entitle you to the dividend. So call value is negatively related to expected dividend.
  - For a put, it's the opposite (put value positively related to dividend rate). While the spot price falls on the ex dividend date by the dividend amount, a put allows you to sell at a fixed K which doesn't fall by the dividend amount.