Tuesday, 31 March 2015
Econophysics

Topic: **Understanding Options and other Derivatives**
-The solution of the Black-Scholes for options
-How options behave

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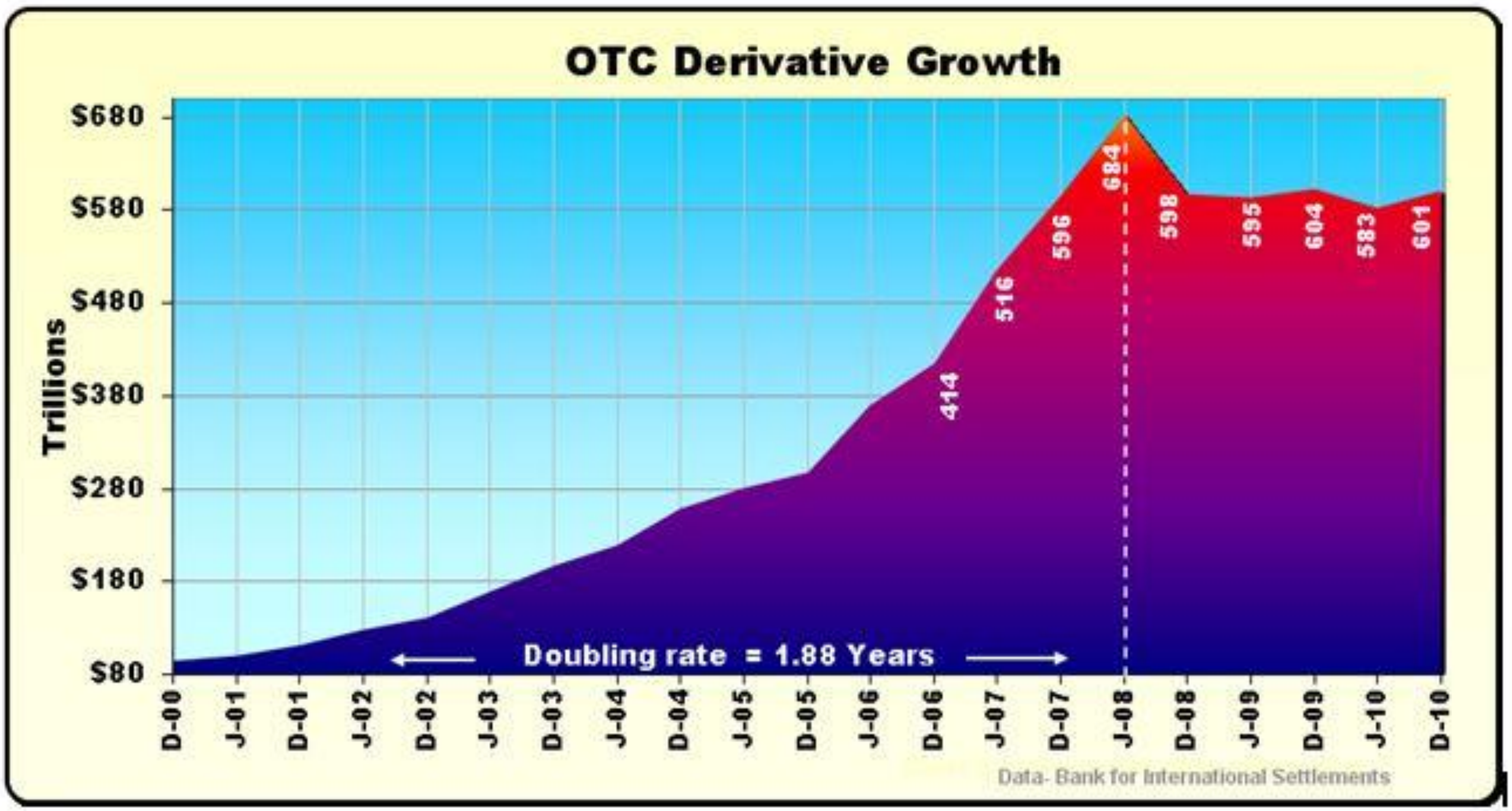
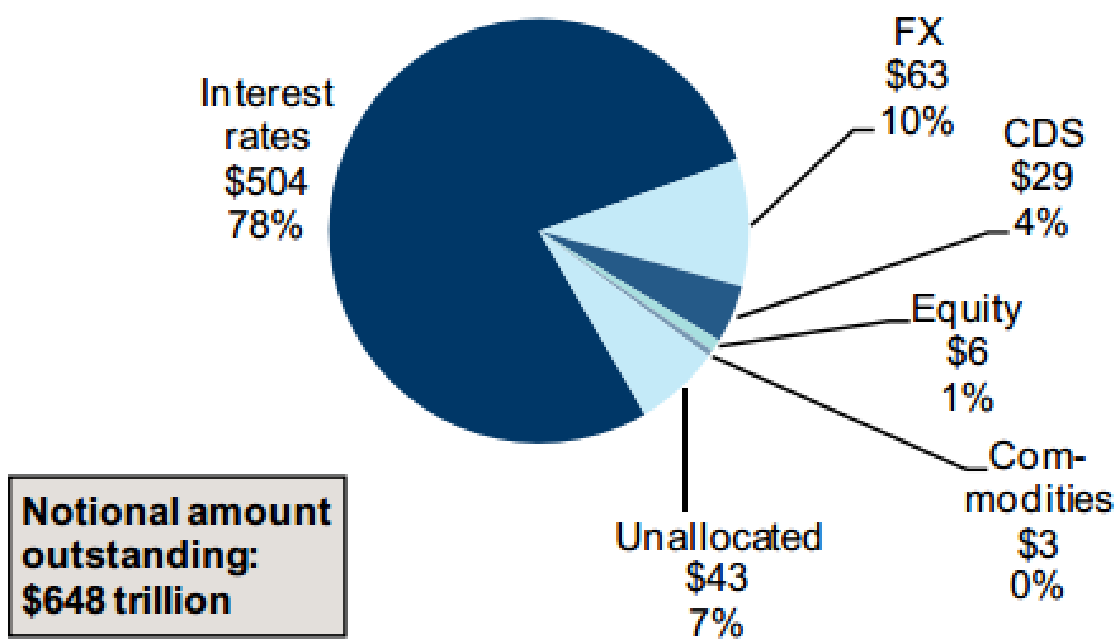
Derivatives market



Notional Outstanding, As of December 2011, US$ in trillions



Source: BIS

Why would you use derivatives?

- Example 1: **You are an owner of an aluminum smelter in Europe.**

- **Aluminum is made from:**
- Electricity
- Bauxite ore
- Work(ers) (☺)
- Other (caustic soda etc.)

- **Aluminum is sold on**:
- London Metal Exchange
- Price is in: dollars (exchange rate risk)

Black–Scholes–(Merton) equation

$$\boxed{\frac{\partial f}{\partial t} + rS\frac{\partial f}{\partial S} + \frac{1}{2}\,\sigma^2 S^2\,\frac{\partial^2 f}{\partial S^2} = rf}$$

Solution for a call option:

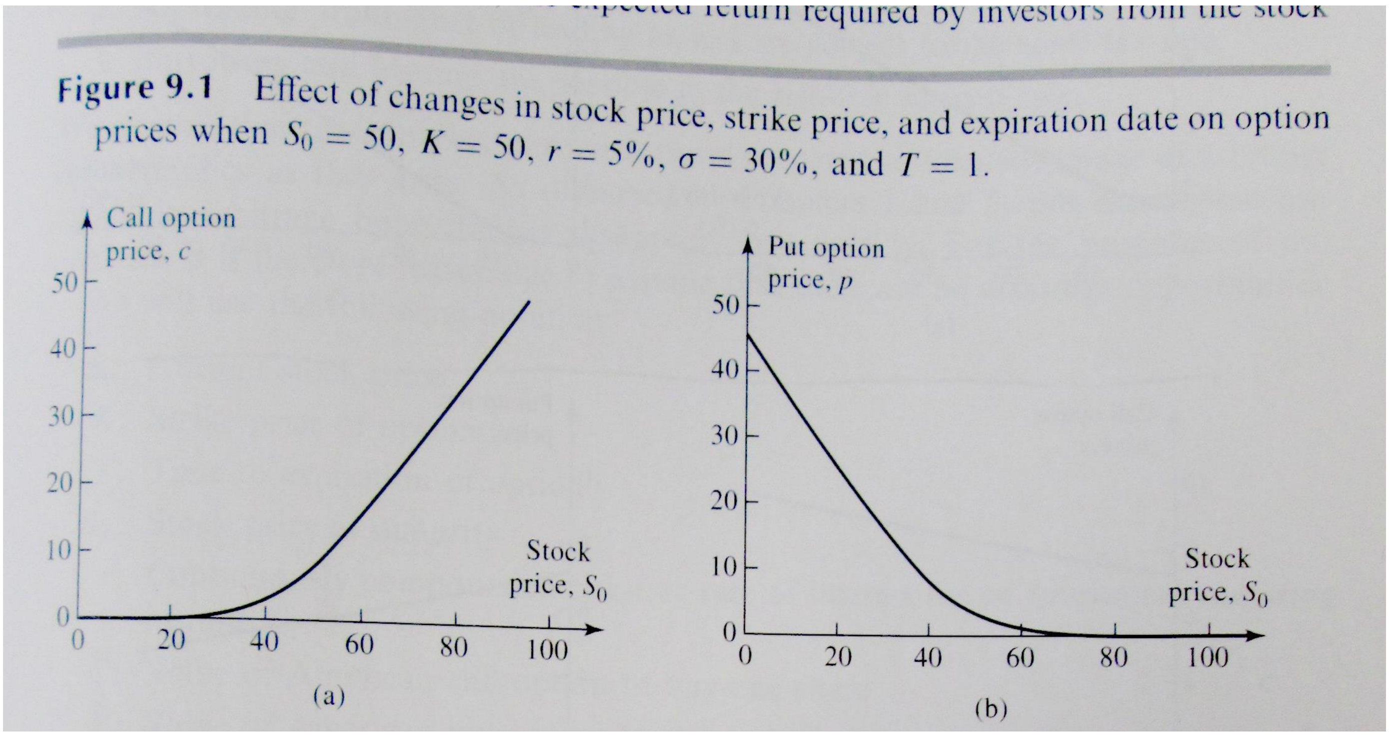
$$\boxed{C(S,t) = N(d_1)S - N(d_2)Ke^{-r(T-t)}}$$

where $$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right]$$

$$d_2 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t)\right]$$

$$= d_1 - \sigma\sqrt{T-t}$$

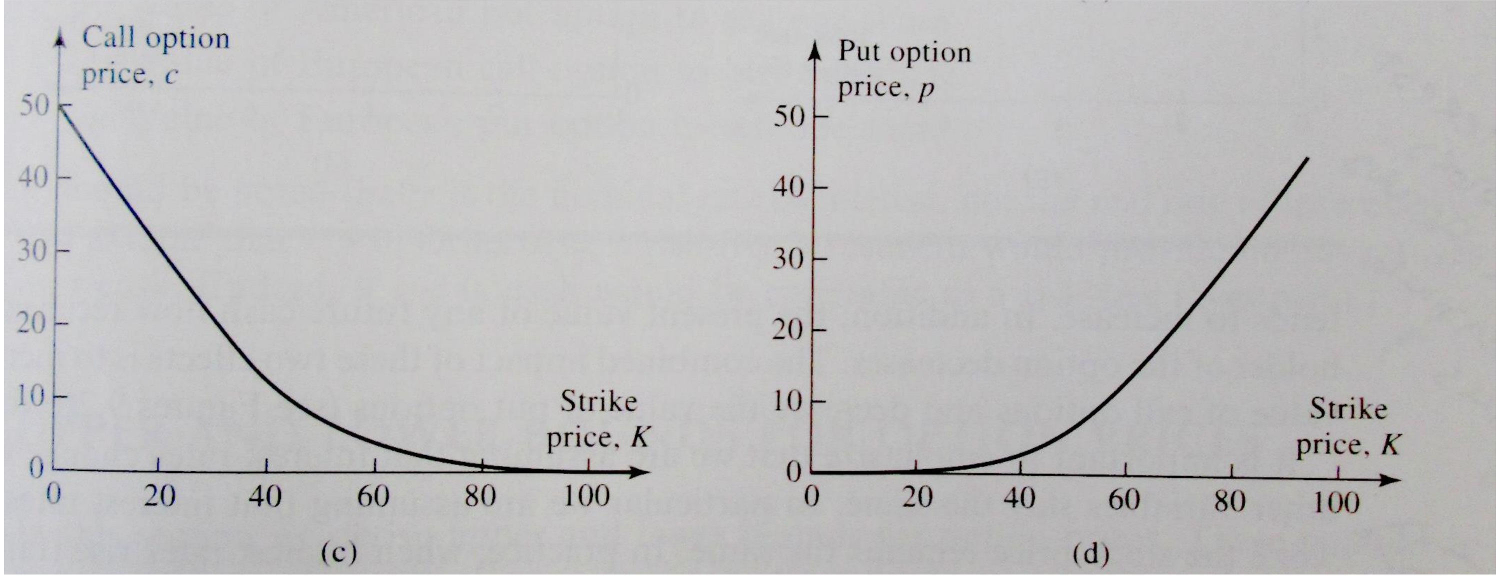
Changing S_0, keeping else constant.



Book: John C. Hull.

Changing K, keeping else constant.

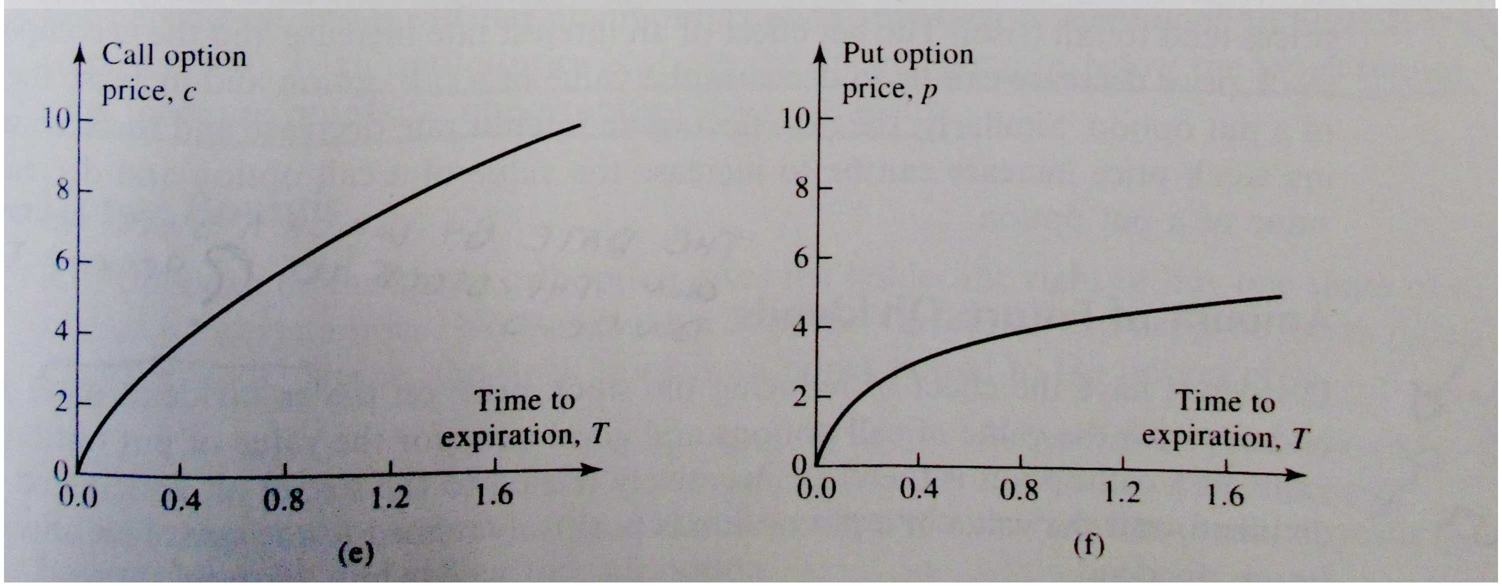
Figure 9.1 Effect of changes in stock price, strike price, and expiration date on option prices when $S_0 = 50$, $K = 50$, $r = 5\%$, $\sigma = 30\%$, and $T = 1$.



Book: John C. Hull.

Changing T, keeping else constant

Figure 9.1 Effect of changes in stock price, strike price, and expiration date on option prices when $S_0 = 50$, $K = 50$, $r = 5\%$, $\sigma = 30\%$, and $T = 1$.



Book: John C. Hull.

Changing volatility, keeping else constant

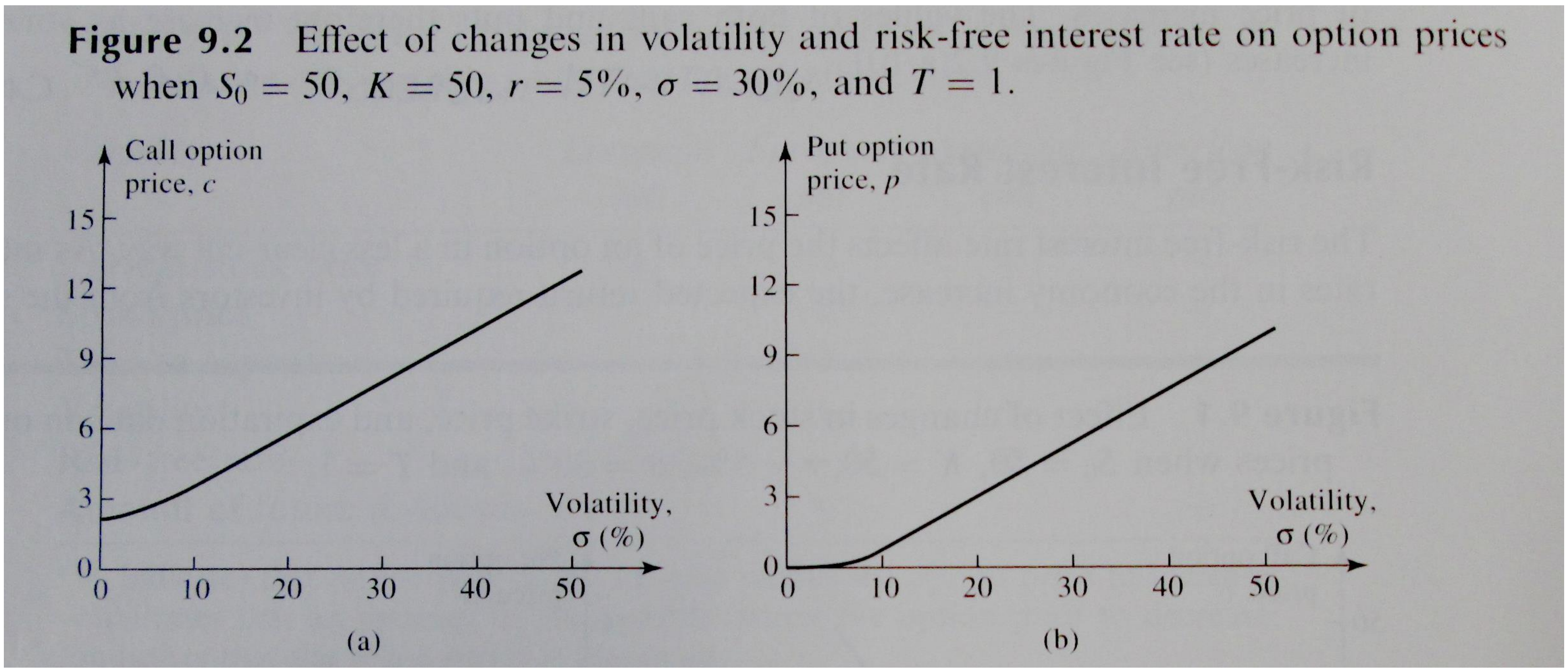
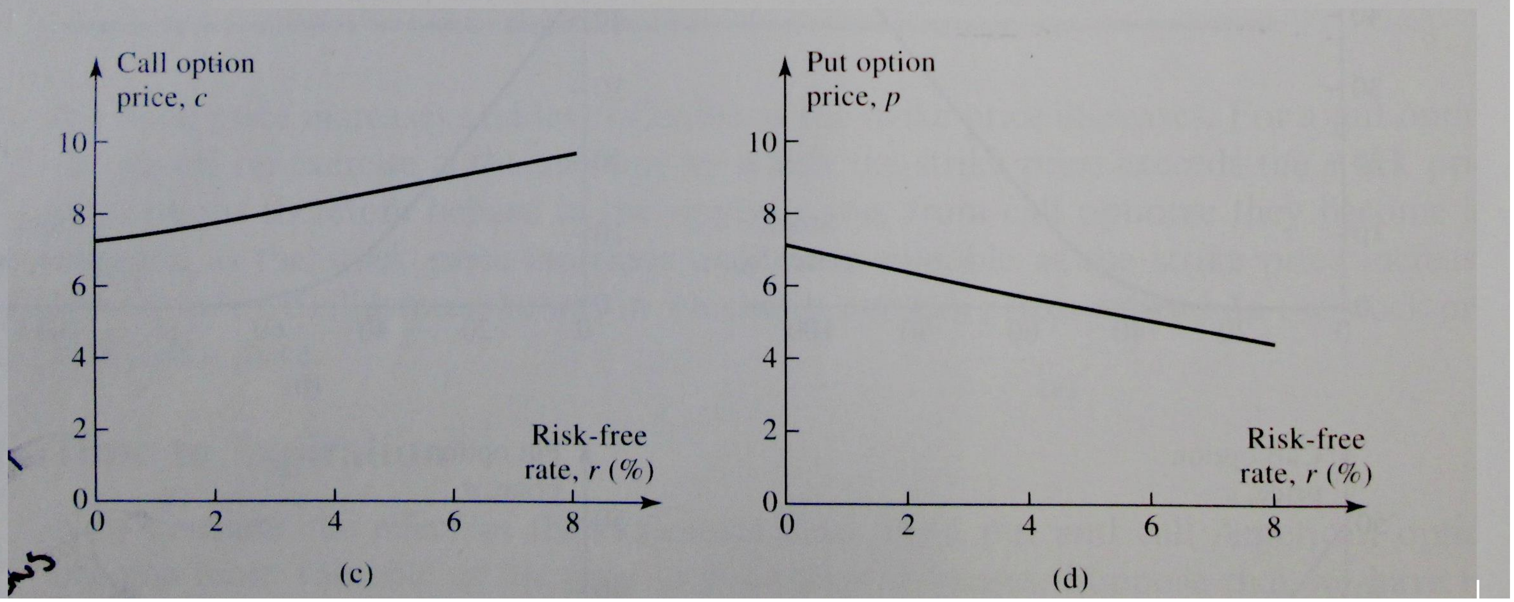


Figure 9.2 Effect of changes in volatility and risk-free interest rate on option prices when $S_0 = 50$, $K = 50$, $r = 5\%$, $\sigma = 30\%$, and $T = 1$.

Book: John C. Hull.

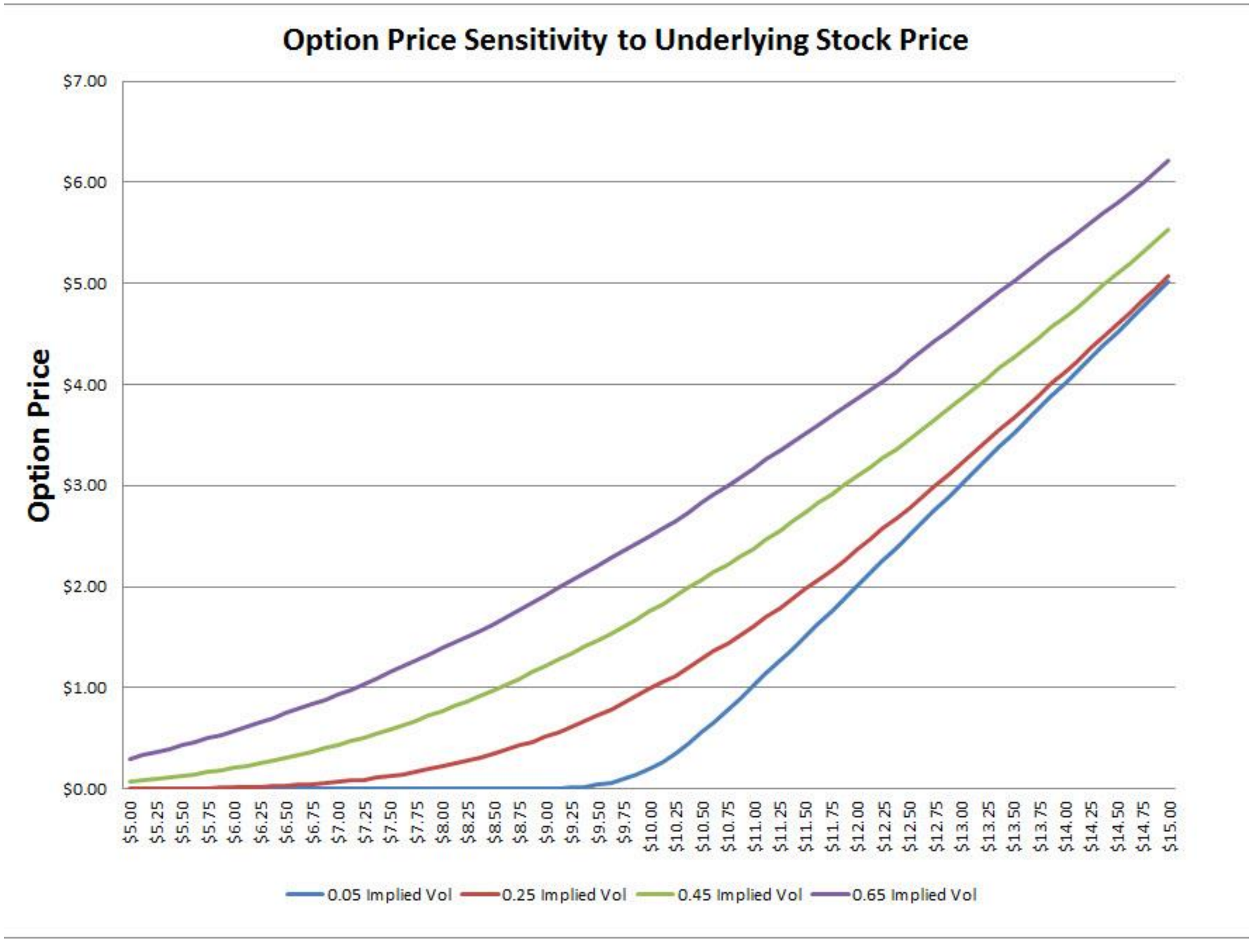
Changing r, keeping else constant

Figure 9.2 Effect of changes in volatility and risk-free interest rate on option prices when $S_0 = 50$, $K = 50$, $r = 5\%$, $\sigma = 30\%$, and $T = 1$.



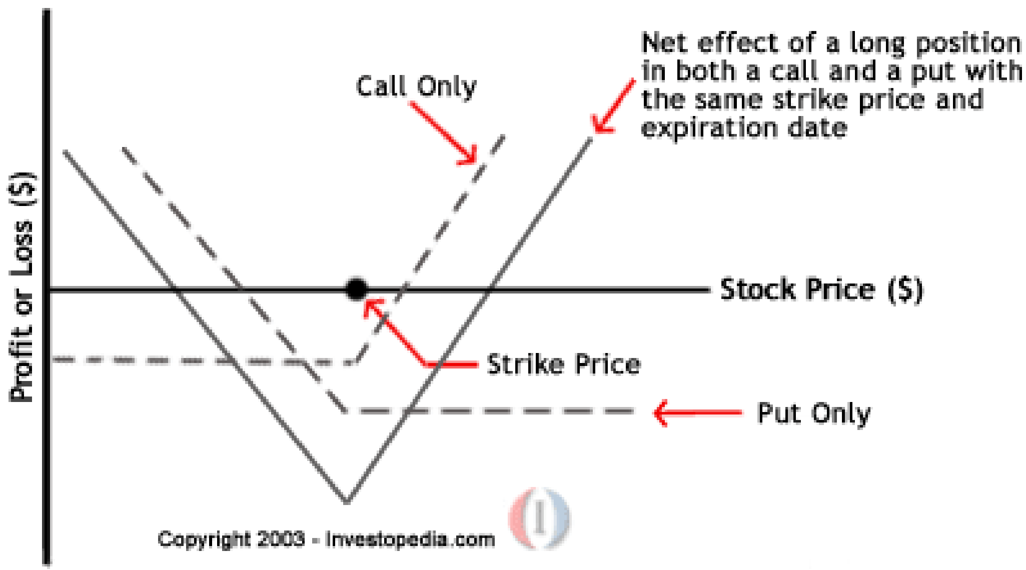
Book: John C. Hull.

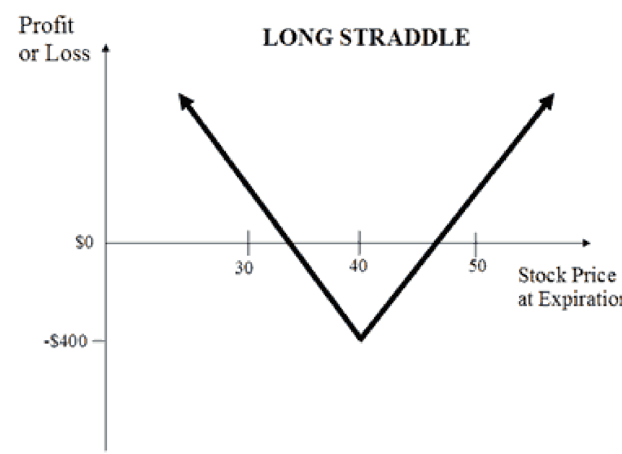
Option price VS volatility



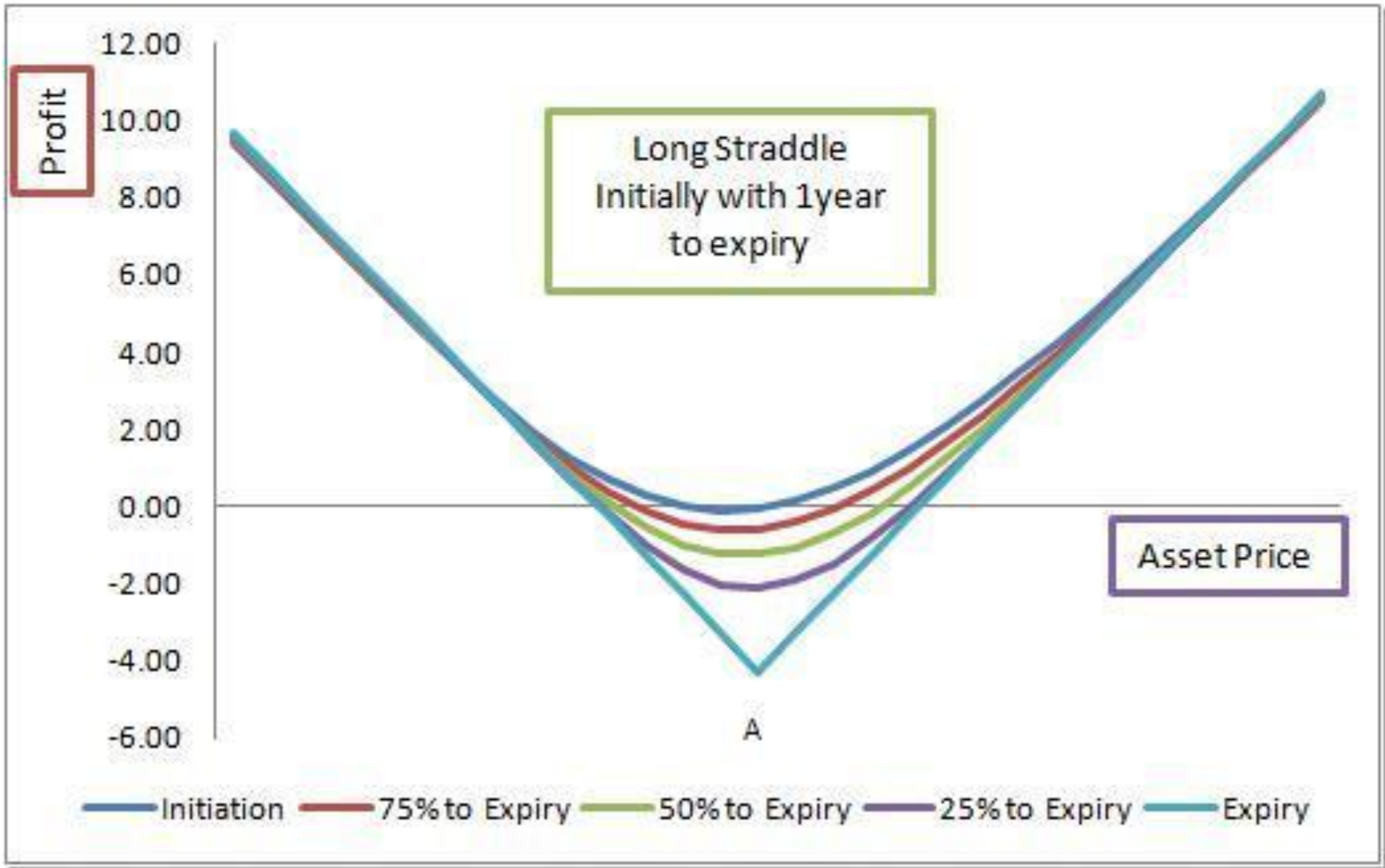
Example of a **derivative**

- Does it make sense to buy both a call and a put?





Its price is positive! This derivative is called STRADDLE


Profit
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
Long Straddle
Initially with 1year
to expiry
Asset Price
A
Initiation
75% to Expiry
50% to Expiry
25% to Expiry
Expiry

Round 10

- Choose a secret integer X between 0 and 15.

Prize= **- $20** **+ 8*|distance to your closest neighbor|**

- You can choose to **fold** (not play this game).
- In that case, write "FOLD" on your paper.
- This is the only round in which you can **freely communicate**.