OPTION VALUATION PART 1

What is an option worth?

Option valuation

- Readings: Chapter 21
- Problems
  - All concept checks
  - Problem sets 2, 5, 6, 8, 9, 21, 24, 26

Outline

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- What are the components of call option value?
- The determinants of call option value (intuition)
- Restrictions on call option values

The components of option value

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- C is the *premium*, the market price of the call with exercise price X, and time to expiration T.
- The *intrinsic value* is the payoff to immediate exercise (or zero, whichever is larger)
  - Intrinsic value = Max(0, S – X)
    - S is the price of the underlying (stock).
- The *time value* of the call is C – Intrinsic value
  - The time value of the call depends on the time value of money (the interest), but it also depends on other things.

With AAPL at 95 … what are the premium, intrinsic value and time value of the 08 Nov 90 call?

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Calls	Last Sale
08 Nov 85.00 (QAA KQ-E)	11.15
08 Nov 90.00 (QAA KR-E)	7.15
08 Nov 95.00 (QAA KS-E)	4.40
08 Nov 100.00 (QAA KT-E)	2.25
08 Dec 85.00 (QAA LQ-E)	14.40
08 Dec 90.00 (QAA LR-E)	11.50
08 Dec 95.00 (QAA LS-E)	8.90
08 Dec 100.00 (QAA LT-E)	6.30

$S - X$

Int Val $= 95 - 90$

$= 5$

$7.15 - 5 = 2.15$

time val

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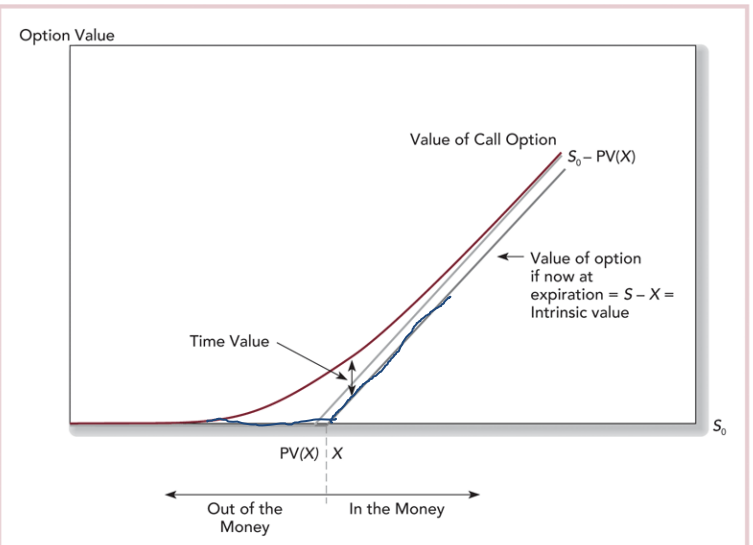

FIGURE 21.1 Call option value before expiration

The determinants of option value, C, (intuition)

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- The stock price *S*
  - S_0 is the current price; S_T is the price at expiration
  - As S_0 ↑, the call either goes deeper in the money or comes closer to being in the money: if S_0 ↑ then C↑
- Exercise price, *X*
  - If the call is in the money and we make X larger, the intrinsic value of the call, S–X, drops: if X↑ then C↓
- Time to maturity, *T*
  - As *T* increases, there is a larger likelihood that the stock price will at some point be higher than it is now: if T↑ then C↑

If stock volatility σ ↑ then C↑.

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- Volatility is usually defined as the standard deviation of the stock's annual return, σ.
  - Volatility is "total risk". The concepts of systematic and unsystematic risk aren't relevant in this context.
  - For a stock that doesn't pay dividends, its entire return comes from price changes (gains or losses).
  - Return volatility is (approximately) the same thing as price volatility.
- High volatility increases the likelihood of a large price swing that would push the option into the money.

If interest rate r↑ then C↑

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- Call options give us leverage
  - A small % increase in the stock price can cause a large % increase in the intrinsic value and market price of a call.
- You can get leverage by buying stock on margin, borrowing $ at a cost r.
- When r ↑,
  - margin borrowing becomes more expensive
  - a call option becomes more attractive as an alternative
  - The call price rises

Restrictions on option values

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- Example: $C \geq \max(S-X,0)$
  - If $C < \max(S-X,0)$ we could make an immediate profit by buying the call and exercising it.
- Why study restrictions on option values?
  - Why not skip right to precise valuation formulas?
  - Valuation formulas are based on models that are only approximately correct.
- Restrictions don't depend on model.

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- $C \geq 0$ (C cannot be negative)
- $C \leq S$ (C cannot exceed the stock value)
  - How large can S – X be?
- For a stock that doesn't pay dividends
  - $C \geq S - PV(X)$

C vs S – PV(X)

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- Call: at expiration $C = \max(S_T - X, 0)$
- S – PV(X)
  - Interpret as a levered position in the stock
    - "buying the stock on margin"
  - To set this up:
    - Buy the stock
    - Borrow $PV(X) = X/(1+r)^T$
  - At maturity T
    - The stock is worth ST
    - We'll repay X
    - Net: $S_T - X$
- Is this better or worse than the call?

Early exercise of an American Call

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- If we exercise the call we get S − X.
- If we hold the call unexercised we have $C \geq S - PV(X)$
- Since $PV(X) < X$
  - $S - PV(X) > S - X$
  - Value of C unexercised > Value of C exercised
  - It is not a good idea to exercise an American call early.
  - The early exercise feature of an American call isn't worth anything.
  - A European call option has the same value as an American call option.
- Note: this is only true for stocks that don't pay dividends before expiration.

The value of a put option

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- Intrinsic value of a put = max(X − S, 0)
- We might want to exercise an American put early.
- Example
  - Suppose X=$50 and S=$1
  - If we exercise immediately, we get 50 − 1 = $49, which can be invested to earn interest
  - If we wait, the only possible benefit is that the stock *might* go lower.
    - But at most we'll get $50

American vs. European puts

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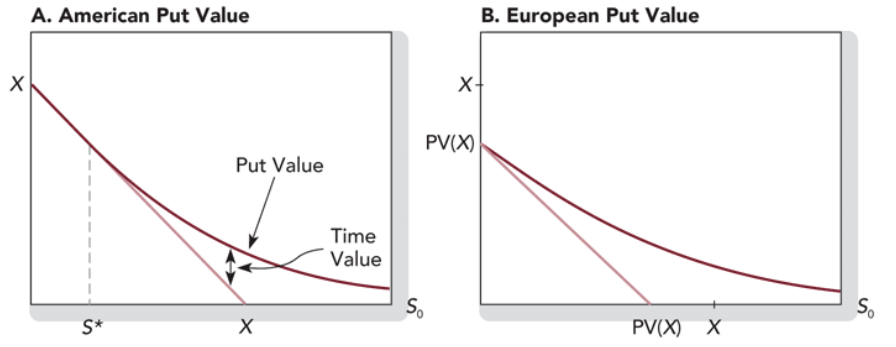

FIGURE 21.4 Put option values as a function of the current stock price