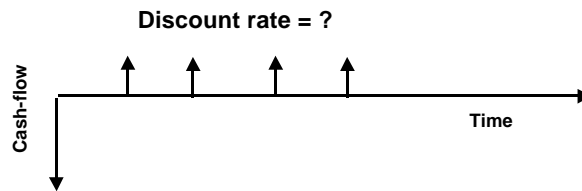

Introduction to Options

Overview

- **Introduction to topic of options**
 - Review key points of NPV and decision analysis
 - Outline topics and goals for options segment of course
 - Options basics
- **Motivation**
 - NPV not suited to valuing of projects with flexibilities
 - Decision analysis with NPV still faces NPV shortcomings
 - Options valuation methodologies aim to resolve these problems

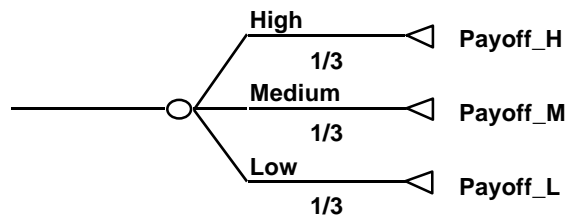
A Review of Project Valuation Methods

- Started with discounted cash-flows (NPV)
- Choice of discount rate important
- Process of selecting discount rate can be difficult
- Utility provide bases for risk adjustment



Certainty is a Rarity

- Need to consider range of possible outcomes
- NPV with expected values & expected NPV not always equal -- See Exercise 2!!
 - Consequences of scenarios have asymmetries
 - Example, production cost versus volume curve not typically linear
- Decision analysis framework considers uncertainties

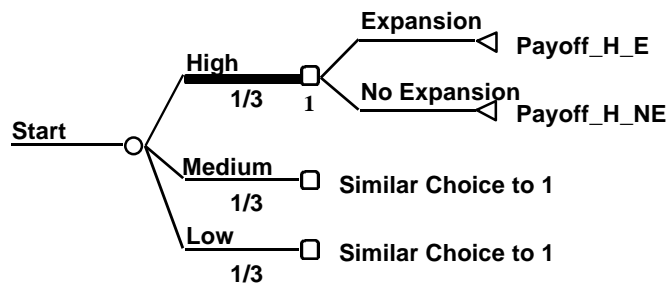


Decisions Not Necessarily Fixed at Project Start

- Many projects have built-in decision points (flexibilities)
 - Expansion
 - Delay
 - Closing
- Choices are made after observation of outcomes

Decisions Not Necessarily Fixed at Project Start

- Decision analysis provides structure for choice evaluation



A Key Lesson from Decision Analysis

- **Flexibility in projects can be extremely valuable**
 - See Exercise 2
- **What drives flexibility value?**
- **Factors to consider might include:**
 - Degree of uncertainty
 - Time restrictions on decision
 - Cost of acquiring flexibility

Real Options Define Value of Flexibility

- **Options valuation well developed for financial markets**
- **Emerging field of real options applies theory to real projects**
 - Future decisions have features similar to financial options
 - Financial options valuation frameworks can be extended to project flexibilities
- **Real options correct deficiencies in NPV & decision analysis**
 - Will detail these deficiencies shortly
 - Will also consider potential drawbacks to real options

Outline for Options Segment of Course

- **Options basics**
 - What is an option
 - Features of financial options
 - Value drivers
- **Valuation of financial options**
 - Boundaries
 - Replicating portfolios
 - The Black-Scholes options pricing model
 - A more generalized approach
- **Real options: extension of options framework to projects**
 - Recognizing real options
 - Examples of valuation in practice
- **Real options compared to decision analysis**

Goals for Options Segment of Course

- **Improve understanding of flexibilities**
 - Value drivers
 - Value estimation
- **Develop introductory background on finance perspective**
- **Explore similarities, differences and limitations**
 - Real options
 - Decision analysis
- **Compare and contrast practical implementation efforts**

What is an Option?

- **A right, but not an obligation...**
 - Asymmetric returns
 - Exercise only if advantageous
 - Acquired at some cost
- **to take some action...**
 - Often buy or sell something
- **now, or in the future...**
 - Usually limited timeframe
 - Option expires after time limit
- **for a pre-determined price.**
 - Price of action separate from option acquisition cost
 - Can be compared to instantaneous benefit of action

Financial Options Basics

- **Focus on stock options**
 - Stock options are tradable assets
 - Sold through exchanges similar to stock markets
 - Options on other assets (e.g. currencies) have similar features
- **Terms of option contract**
 - Owner acquires option
 - Option provides right to buy or sell stock
 - Time period during which option can be exercised is limited
 - Strike price at which stock is bought or sold is pre-determined in contract

Financial Options Basics

- **Example**

- Purchase 1-year option to buy 100 shares of X-cape at \$100/share
- Likely to exercise if stock trades above \$100
- Not required to exercise (losses limited)

Financial Options Terminology

- **Two types of stock options**

- Call: right to BUY stock for a set strike price, at or within a certain timeframe
- Put: right to SELL stock for a set strike price, at or within a certain timeframe

- **Constraint on exercise defines two forms of stock options**

- European: exercise only on expiration date
- American: exercise at any time on or before expiration date

Financial Options Terminology

- **Payoff versus value**
 - Payoff is value if exercised immediately
 - Value of option often exceeds immediate exercise payoff
- **American options more representative of real life options**
 - Most decisions can be made at any time
 - Remaining discussion focuses on American options, unless otherwise noted

Factor Definitions

- **S = stock price (S* is price at option point of exercise)**
- **K = strike price at which stock is bought (call) or sold (put)**
- **t = time remaining until option expires**
- **β = standard deviation of returns for stock (volatility)**
- **r = risk-free rate of interest**

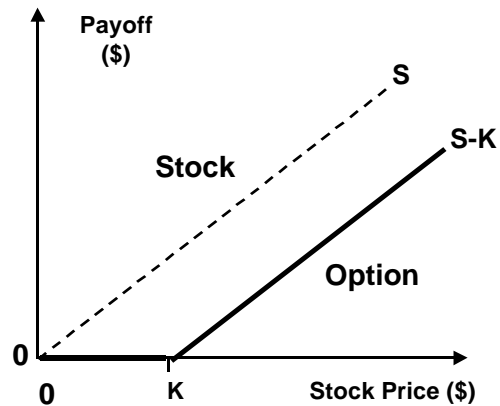
Uncovering the Sources of Value in Options

- Presented a number of terms and definitions
- Working toward placing an exact value on options
- Need to build up to valuation
 - Identify interesting features
 - Examine influences of value
 - Combine findings into valuation framework
- Start by looking at payoffs from options
 - Suggested that payoff and value might be different
 - Payoff structure does have influence on value

Call Option Payoff

- If exercised, call option owner buys stock for a set price
 - Get stock worth S^* dollars
 - Pay strike price of K dollars
 - Net position = $S^* - K$
- If unexercised, net payoff is zero
- Maximum of either 0 or $S^* - K$ = net payoff for call
- Net payoff for call = $\text{Max} [0, S^* - K]$

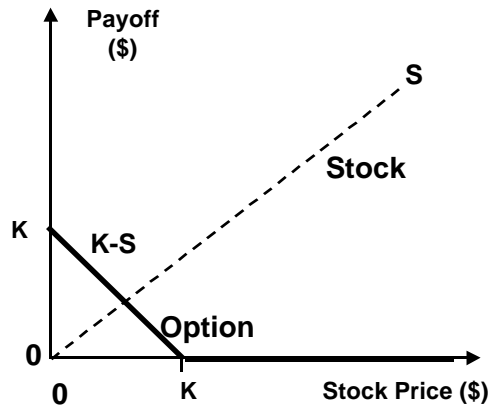
Payoff Diagram for Call Option



Put Option Payoff

- If exercised, put option owner sells stock for a set price
 - Sell stock worth S^* dollars
 - Receive strike price of K dollars
 - Net position = $K - S^*$
- If unexercised, net payoff is zero
- Net payoff for put = $\text{Max}[0, K - S^*]$

Payoff Diagram for Put Option



Valuation of Options

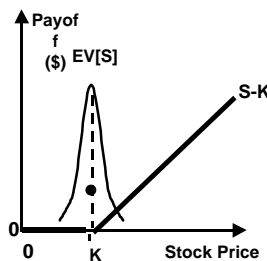
- How much should you pay to acquire an option?
- Payoff diagrams show for a given strike price
 - Call payoff increases with stock price
 - Put payoff decreases with stock price
- Immediate payoff may not reflect full value of option
 - Owner exercises only when advantageous
 - Must compare immediate exercise value with waiting

Why Immediate Payoff and Value Might Differ

- Consider an at the money option ($S=K$)
Immediate exercise payoff is zero
Positive payoff might be obtained by waiting
Worst outcome of waiting is zero payoff (same as immediate exercise)

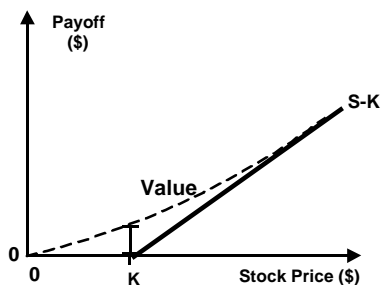
Value in ability to wait not reflected in immediate exercise

• = value of option



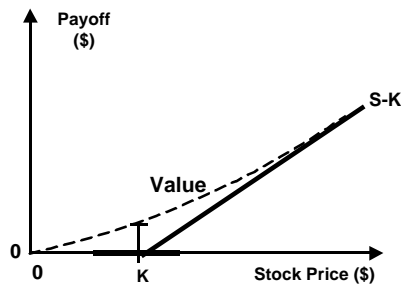
Examining Value for All Stock Prices

- Value exceeds immediate exercise payoff
- Asymptotically approaches payoff for increased S
- Incentive to lock in gain becomes significant



Examining Value for All Stock Prices

- Approaches zero as stock price nears zero
 - Option is worthless if stock reaches zero
- What influences difference between value & immediate payoff?



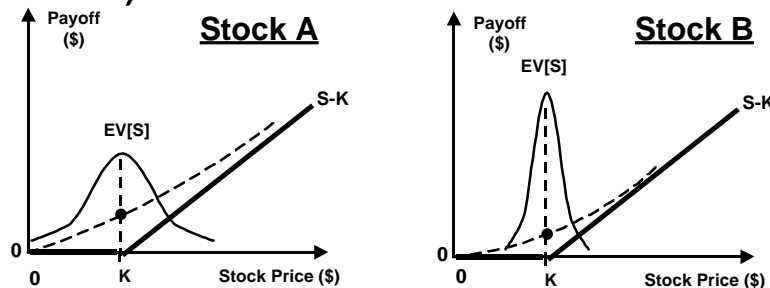
Engineering Systems Analysis for Design
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Option Value Increases with Volatility

- Two at the money options ($S=K$)
 - * Both have 50% chance of zero payoff
 - * Underlying with greater volatility has more opportunity for large payoffs

Asymmetric returns favor high variation (limited losses)



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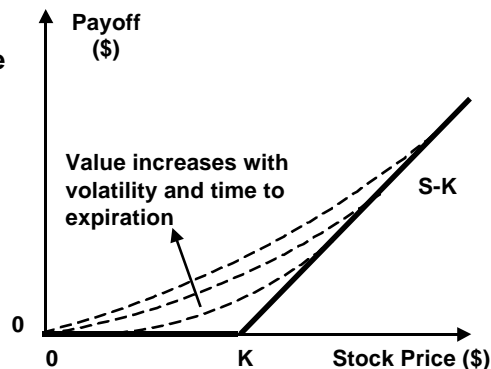
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Impact of Time

- **Increasing time to expiration increases option value**
 - Ability to wait allows option owner to benefit from asymmetric returns
 - Longer-term American option contains shorter-term options, plus more time
- **Compare a 3 and 6 month American call**
 - Can exercise 6 month call at same time as 3 month
 - Can wait longer with 6 month
 - Which is more valuable?
- **Time impact less clear for European options**
 - Forced to wait to exercise
 - Could miss out on profitable opportunities

Generalized American Call Option Value

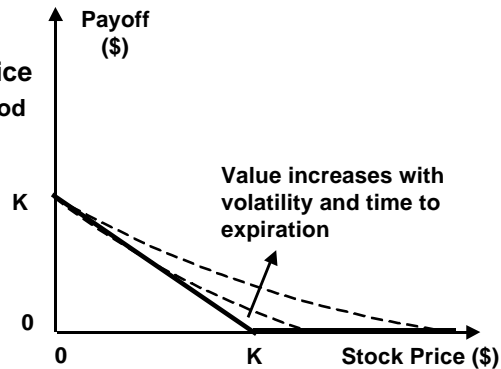
- **For a set strike price, call option value increases with**
 - Stock price increases
 - Volatility
 - Time
- **Increased strike price**
 - Reduces likelihood of payoffs
 - Reduces call option value



Generalized American Put Option Value

- For a set strike price, put option value increases with
 - Stock price declines
 - Volatility
 - Time

- Increased strike price
 - Increases likelihood of payoffs
 - Increases put option value



Implications for Real Options

- Some factors influence options value in the same way
 - Options more valuable for risky projects (higher volatility)
 - Options more valuable for long-term efforts
- Influence of other factors depends on the type of option
 - Exercise (strike) price
 - Changes in underlying asset value (stock)
- Need to distinguish real options by type
 - Call-like
 - Put-like

Summary of Financial Options Basics

- **Options provide rights, not obligations**
 - Asymmetric returns (exercise only if advantageous)
 - Potential loss limited to acquisition price
- **Option payoff based on**
 - Underlying stock price (S)
 - Strike price (K)
- **Critical question: How much to pay for Options?**
 - Stock price and strike price matter
 - Value of American options increases with time and volatility
- **Next sessions, explore frameworks for exactly valuing options**