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

![Discount rate diagram]

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

![Decision tree diagram]
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

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Decision analysis provides structure for choice evaluation

![Decision Tree Diagram]

- **Start**
  - **High**: 1/3
    - Expansion
      - Payoff \( H_E \)
  - **No Expansion**: 1
    - Payoff \( H_{NE} \)
  - **Medium**: 1/3
    - Similar Choice to 1
  - **Low**: 1/3
    - Similar Choice to 1
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
- **\(\beta\)** = 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

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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 $S^* - K = \text{net payoff for call}$

- Net payoff for call = Max [0, $S^* - K$]
Payoff Diagram for Call Option

- 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 = Max [0, $K - S^*$]
### Payoff Diagram for Put Option

![Payoff Diagram for Put Option](image)

### 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 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?

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)
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

\[
\text{Payoff ($)} = \begin{cases} 
0 & \text{if } S < K \\
S - K & \text{if } S > K 
\end{cases}
\]

Value increases with volatility and time to expiration
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

Value increases with volatility and time to expiration

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