Real Options

Introduction

- Developed an introduction to financial options
  - Features
  - Payoffs
  - Value drivers and valuation

- Options require special valuation frameworks
  - Not possible to simply discount cash-flows
  - Level of risk changes continuously
  - Black-Scholes and binomial model provided solutions

- Today, introduce topic of real options
  - Real projects have option-like features
  - Similar to financial options, NPV does not correctly value project options
  - Real options aims to correct NPV deficiencies
Outline for Real Options

- **Major topics**
  - Examples of options encountered in everyday life
  - Real options defined
  - Features of several generic real options
  - Comparisons of valuation in practice
  - Pros and cons of real options and decision analysis
  - Wrap-up and pointers to other courses and materials

- **Goals**
  - Increase ability to recognize real options
  - Improve understanding of when it is valuable to build options into projects
  - Compare and contrast different opinions on how to value

Option Definition Revisited

- **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
Options are Not Limited to Traded Securities

- Lease car with option to buy
  - Leasee decides at end of contract
  - Action is to buy car at end of lease (or to walk away)
  - Lease period defined up-front (typically 2-3 years)
  - Car purchase price defined in lease contract

- Flexible manufacturing processes
  - Ability to select mode of operation (e.g. heater that burns gas or oil)
  - Switching between modes is action
  - Continuous opportunity (can switch at any time)
  - Switching modes often entails some cost (e.g. set-up time)

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A Common, Option: Insurance

- Insurance policy
  - Small annual premium provides protection from potential losses
  - Payoff equals amount of damage (minus a deductible)
  - Claim is filed (option exercised) if damage total exceeds deductible

- Payoff is different from value
  - On average, expected net payoff to policyholder is less than premium
  - Otherwise insurance companies go bankrupt
  - People still buy insurance, because they are risk averse
  - Implies value exceeds expected payoff
A Payoff Diagram for Insurance

- Maximum payoff is insured value minus deductible
- Minimum payoff is zero
- Payoff resembles put option

$$A = \text{Insured Value}$$
$$K = \text{Insured Value-Deductible}$$
$$A-K = \text{Deductible}$$
$$B = \text{Value After Disaster}$$

Boundaries on Insurance Value

- Insurance premium approximates value
  - Willingness to pay for protection
  - Reflects value to least risk-averse policyholder

- Can identify boundaries on the premium

- Upper bound is value of apartment less deductible
  - Even if total loss is certain, this is the limit of the payoff
  - Since damage is uncertain, premium will be less

- Lower bound is zero
  - Insurance companies are in business to make money

- If insuring already damaged property were possible
  - Lower bound would exceed immediate payoff (exercise value)
Approximate Estimate of Insurance Value

- Payoff increases with:
  - Reduction in value of property
  - Decreases in deductible (increases in strike point)
  - Timeframe of policy
  - Likelihood of damage occurring

Same general trends as a put option

Insurance is like a put option on the insured property
Real Options Defined

- Projects often contain option-like flexibilities
  Rights, not obligations
  Provide asymmetric returns, exercise only if advantageous

NPV not suited to valuing flexibilities
- Project risk is different at each decision point
- In reality, decisions can be made at any time
- Difficult to identify proper, risk-adjusted discount rate

In practice, flexibilities ignored in project evaluation
- Focus on expected values
- Assumes decisions not possible, or pre-determined

Real options aims to include valuation of flexibility
- Applies options methodologies to value project options
- Provides more informed basis

A Real Options Example

- Option to abandon a project
  - R&D can be pursued in phases
  - Initial efforts can be small
  - Information from each phase informs subsequent decisions
  - Continue only if promising

- Traditional project evaluation focuses on expected values
  - How much money required to fully develop
  - Market potential for commercial product

- Tremendous value may lie in ability to make future decisions
An Example of Flexibility Value
(Option to Abandon)

- Start R&D project for $100
- $1100 more will be required to complete development
  - Must decide whether or not to continue after observing initial results
  - Commercial feasibility determined by initial R&D results
  - Plan to sell (license) technology to highest bidder
- Revenue estimate
  - 50% chance to sell technology for $2000
  - 50% chance to sell for $100
- Assume constant 10% discount rate applies

**Fund project?**

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<tr>
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Traditional Valuation
Traditional Valuation (2)

- \( NPV = -232 \)
- Project should be rejected

```
Fund (100) ⇒ Com Good (1100/1.1^2)
        \( 0.5 \)
        2000/1.1^2

Fund (100) ⇒ Com Bad (1100/1.1^2)
        \( 0.5 \)
        100/1.1^2

Do Not Fund

Com Good (1100)                        Com Bad (1100)
        \( 0.5 \)                          \( 0.5 \)
```

Flexibility Perspective

- Finish developing only if $2000 license is expected

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Flexibility Perspective (2)

- **NPV = +226**
- **Should accept project**

![Decision Tree Diagram]

**Comments on Example**

- Ability to abandon project had significant value
  - Limited downside
  - Continue only if advantageous

- Standard NPV missed option value completely

- Decision analysis valuation not strictly correct in finance view
  - Project risk changes with presence of option to abandon
  - Decision analysis approach provides no basis for discount rate adjustment
  - Decision analysis provided a significant conceptual improvement

- Mechanics of applying options theory complex
  - Defer issue for now; Outline several general real options
  - Move to discussion of valuation practice to illustrate differences in approaches
Several Generic Real Options

- Examine three classes of generic options

- Call-like
  - Permit holder to capture benefits from increases in project value
  - Exercise typically involves putting more money into project
  - Exercise when expectations of positive return increase

- Put-like
  - Permit insurance against losses from decreased project value
  - Exercise may involve short-term costs or salvage value
  - Exercise when expectations of positive return decrease

- Compound (nested)
  - Projects might contain multiple options
  - Exercise decisions based on overall profit maximization

Call-Like Real Options

- Waiting to Invest
  - A project might seem profitable today, but waiting could be even more valuable
  - Leaving open the opportunity to invest is like holding a call
  - Influences include uncertainty resolution and foregone profits
  - Choice based on: Max [immediate investment, waiting, 0]

- Expand
  - Accelerate effort or broaden level of involvement
  - Allows greater participation in upside by increasing exposure
  - Cost of expansion acts like strike price
  - Choice based on: Max [status quo, expanded project]

- Restart Temporarily Closed Operations
  - Similar to waiting to invest or expand (a special case)
  - Choice based on: Max [remain closed, re-open]
Put-Like Real Options

- **Abandon**
  - Ability to halt further investment
  - Eliminates further exposure
  - Abandoning might include shut-down costs and salvage values
  - Choice based on: Max [continuing, abandoning]

- **Contract**
  - Decelerate or narrow involvement
  - Reduces participation level and exposure to potential losses
  - Often incur short-term scale down costs
  - Choice based on: Max [status quo, contracted]

- **Temporarily Shut Down Operations**
  - A special case of contraction
  - Eliminates exposure to variation, but might incur shut-down costs
  - Choice based on: Max [status quo, temporarily shut-down]

Compound or Nested Options

- **Combinations of Options**
  - Many real options exist simultaneously
  - Example, can often choose between abandon, contract, or temporarily shut
  - Complex problem because value of multiple real options may not be additive
  - Values of above listed options interdependent
  - Exercise may render others valueless (abandon ends project)

- **Switching Between Modes of Operation**
  - Flexible systems contain an infinite series of options
  - Allow continual switching between modes of operation
  - If switching modes has a cost, it acts like a strike price
  - Will discuss example of a dual-fuel boiler burner

- **For compound options, must value as system**
Choosing a Real Options Valuation Basis in Practice

- Compare efforts at two companies
  Merck (financial options)
  Kodak (decision analysis)

Examine factors that influenced choice
  Business/industry structure
  Type of information available

Is goal precise valuation or estimation?

Key findings
  Importance is recognizing presence of real options
  Valuation is a balance between "precision" and implementability

Real Options at Merck

- Merck values real options using financial frameworks
  - Black-Scholes formula
  - Other models for support (monte-carlo simulation)
  - Applies to variety of areas: R&D and acquisitions specifically mentioned

- Example: Gamma project
  - Options used to value a development contract with a biotech company
  - Investment in R&D created option for future scale-up and commercialization
Real Options at Merck (2)

- **Project Gamma as a call option**
  - Value of project cash flows acted as underlying asset (stock equivalent)
  - Cost of manufacturing scale-up comparable to strike (exercise) price
  - Time before expiration was varied between 2-4 years
  - Risk-free rate based on U.S. Treasuries
  - Volatility was varied between 40-60 percent (based on biotech stock database)

Real Options at Kodak

- **Kodak often values real options using decision analysis**
  - Understanding financial frameworks informs process
  - Occasionally, might use more strict financial framework

- **Example: color printer project**
  - R&D project faces technical and market uncertainties
  - Must decide separately if R&D and commercialization are worth pursuing
  - R&D creates option to commercialize
Real Options at Kodak (2)

- Color printer project as a real option
  - Project cash-flows serve as underlying asset
  - Commercialization scale-up costs act as strike price
  - Timeframe is two years (1993-1995)
  - Discount rate of 12% used
  - Volatility of payoffs implied by considering range of outcomes

Drivers of Framework Selection: Business Structure

- Merck
  - Pharmaceutical development process highly regulated
  - All products travel through same path to market (10-11 years to FDA filing)
  - Reasonable to speak in terms of an average project and estimate volatility
Drivers of Framework Selection:
Business Structure (2)

- **Kodak**
  - Involved in multiple businesses: film, imaging, printing, etc.
  - Product development processes might be similar, but do have variation
  - Hard to think of what an average project might be

Drivers of Framework Selection:
Information Availability

- **Merck**: structure yields significant historical information
  - Average drug takes $359 million and 10 years to market
  - 1/10,000 compounds tested becomes a drug
  - Fraction of population with disease X known (especially with Medco acquisition)
  - Successes and failures at each testing step documented and averaged
  - Database of pharmaceutical and biotech stock performance created

- **Kodak**: less homogeneous historical project data
  - Significant variation between and within business units
  - Not impossible, but more difficult to assemble relevant databases
  - Projects might vary widely from averages anyway
Goals of Applying Options Valuation at Merck and Kodak

- Companies recognize that project options are valuable

- Mind-set more important than precision
  - Kodak states this explicitly
  - Merck does sensitivity analysis (varies volatility and time)

- Valuation framework selected based on ease of implementation
  - Merck finance department uses financial models and has requisite data
  - Kodak R&D department uses decision analysis on a case by case basis

- Hard to argue that one or the other is more precise
  - Mis-priced financial options create arbitrage opportunities
  - Error in real options value estimation less obvious
  - Sensitivity analysis helps to address remaining uncertainties

Summary

- Real options encountered in projects and daily life

- Real options can be in 1 of 3 general forms
  - Call-like (opportunities to increase commitment)
  - Put-like (opportunities to insure or decrease commitment)
  - Compound (many options influence project simultaneously)

- Compared finance models and decision analysis
  - Decision analysis suffers from discount rate problem of options
  - Application of finance models still carries uncertainty
  - Merck and Kodak decided based on their unique operating environments