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)

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

![Diagram]

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

**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?

### Traditional Valuation

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Traditional Valuation (2)

- NPV = -232
- Project should be rejected

```
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Flexibility Perspective

- Finish developing only if $2000 license is expected

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Flexibility Perspective (2)

- NPV = +226
- Should accept project

```
Fund (100) ->
  0.5 Good -> Com (1100/1.1) -> 2000/1.1^2
  0.5 Bad -> Com (1100/1.1) -> 100/1.1^2
Abandon -> 0
```

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

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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