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

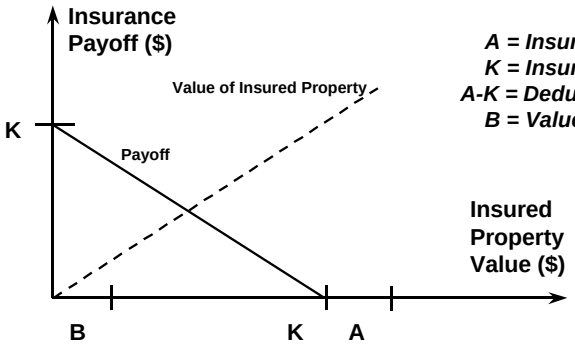
- **Lease car with option to buy**
  - Leasee decides at end of contract
  - Action is to buy car at end of lease (or to walk away)
  - Lease period defined up-front (typically 2-3 years)
  - Car purchase price defined in lease contract
- **Flexible manufacturing processes**
  - Ability to select mode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

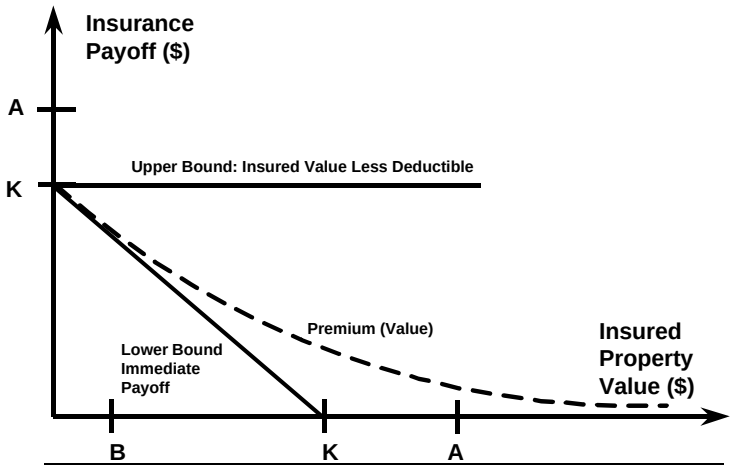


A = Insured Value
K = Insured Value-Deductible
A-K = Deductible
B = Value After Disaster

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



Note Features of Insurance

- **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)

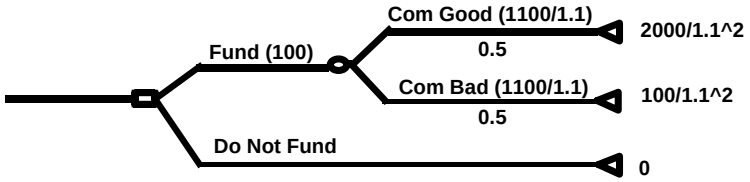
- Start R&D project for $100
- $1100 more will be required to complete development
  - Must decide whether or not to continue after observing initial results
  - Commercial feasibility determined by initial R&D results
  - Plan to sell (license) technology to highest bidder
- Revenue estimate
  - 50%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

Traditional Valuation

Year	0	1	2
Initial Cost	(100)		
Continuing Cost		(1100)	
License Revenues			0.5*200 0.5*100
Present Value	(100)	(1000)	868

Traditional Valuation (2)

- *NPV = -232*
- *Project should be rejected*



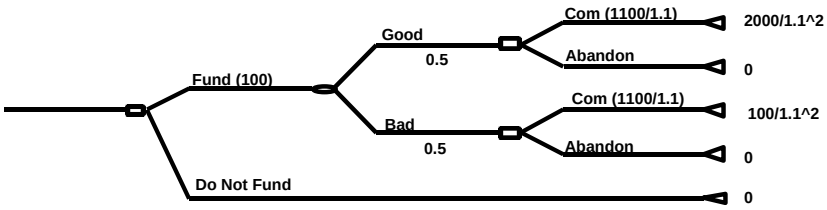
Flexibility Perspective

- **Finish developing only if $2000 license is expected**

Year	0	1	2
Initial Cost	(100)		
Continuing Cost		0.5*(1100)	
License Revenues			0.5*200 0.5* 0
Present Value	(100)	(500)	826

Flexibility Perspective (2)

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



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

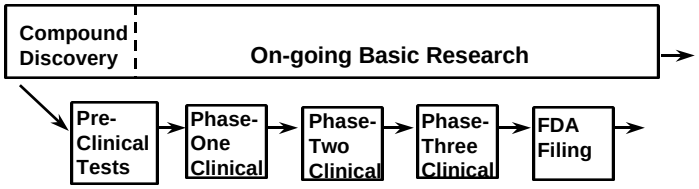
- **Kodak often values real options using decision analysis**
  - **Understanding financial frameworks informs process**
  - **Occasionally, might use more strict financial framework**
- **Example: color printer project**
  - **R&D project faces technical and market uncertainties**
  - **Must decide 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