Real Options

Richard de Neufville
Professor of Systems Engineering and of
Civil and Environmental Engineering
MIT

Outline for Real Options

- **Major topics**
  - **Real options defined**
  - **Examples of real options plentiful in everyday life**
  - **Features of several generic real options**
  - **Comparisons of valuation in practice**
- **Goals**
  - **Increase ability to recognize real options**
  - **Compare and contrast some different approaches to valuation and use of real options**

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...
  - Financial options generally have a limited time
  - Design Options may not have limits
- for a pre-determined price.
  - Price of action separate from option acquisition cost
  - Can be compared to instantaneous benefit of action

Real Options Defined

- Projects often contain option-like flexibilities
  - Rights, not obligations
  - Providing Asymmetric Returns, Exercise only if advantageous
- These flexibilities are "real" options
- Traditional NPV analysis has ignored these options
  - Assumes decisions not possible or are pre-determined
  - Disregards the effect of intelligent management
- "Real Options" analysis includes valuation of flexibility
  - Applies some form of Options Analysis
- Systematically increases value of projects, especially for development projects with greater uncertainties
  - Ex: R & D, new technologies, etc.

Real Options are Common

- **Examples:**

- **Lease car or equipment with option to buy**
  - **Person with lease decides at end of contract**
  - **Action is to buy at end of lease (or to walk away)**
  - **Lease period defined up-front (typically 2-3 years)**
  - **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)**

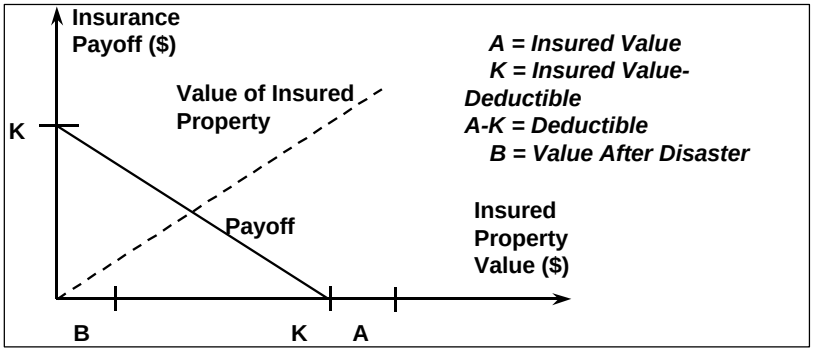
A Common Option: Insurance

- **Insurance policy**
  - **Small annual premium protects 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

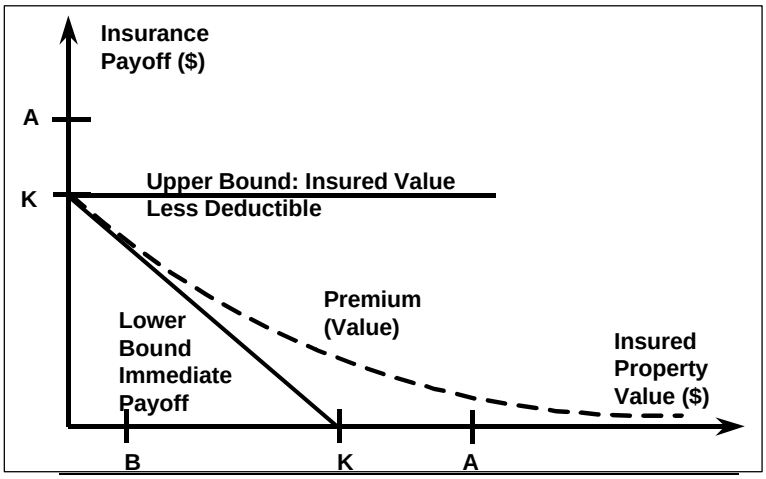
- Maximum payoff is insured value minus deductible
- Minimum payoff is zero
- Payoff resembles put option



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)

Estimate of Insurance Value



Features of Insurance

- Payoff increases with
  - Reduction in value of property
  - Decreases in Deductible (increases in strike price)
  - Time Frame of Policy
  - Likelihood of Damage Occurring
- Same Trends as a put option
- Insurance is like a put option on the insured property

Several Generic Real Options

- **Call-like**
  - Capture benefits from increases in project value
  - Exercise typically involves putting more money into project
  - Exercise when expectations of positive return increase
- **Put-like**
  - Insure 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 be profitable today, but even better tomorrow
  - 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

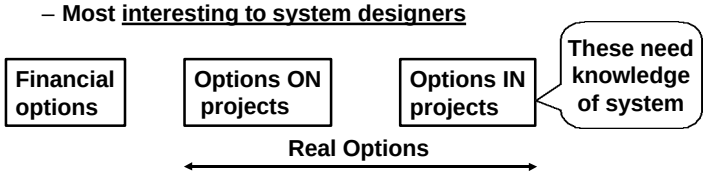
- **Abandon**
  - Ability to halt further investment eliminates further exposure
  - Abandoning might include shut-down costs and salvage values
  - Choice based on: Max [continuing, abandoning]
- **Contract**
  - Decelerate or narrow involvement
  - Reduces participation level and exposure to potential 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
  - For Example: can often choose between abandon, contract, or temporarily shut
  - Complex problem because value of multiple options not additive
  - Values of above listed options interdependent
  - Exercise may render others valueless (abandon ends project)
- **Switching Between Modes of Operation (example: dual fuel burner case)**
  - 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
- **For compound options, must value as system**

Two Types of Real Options

- Those "real" because, in contrast to financial options, they concern projects, they are "ON" projects
  - EX: the option to open a mine (Antamina case)
  - These do not concern themselves with system design
  - Most common in literature
- Those "real" because they concern the design elements of system, they are "IN" projects
  - EX: options for staging of system of communication satellites
  - These require detailed understanding of system
  - Most interesting to system designers



Real Options "on" projects

- These are financial options, but on technical things
- They treat technology as a "black box"
- Example: Antamina mine
  - Successful bidder acquires the option to develop the mine after a two-year exploration period
  - Uncertainty concerns amount of ores and their future price, which combine to determine uncertainty in revenue and thus in value of mine
  - Option is a Financial Call Option (on Mine as asset)
- Differs from Financial Option because
  - Much longer period than financial option
  - Special effort needed to model future value of asset, it can't be projected simply from data on past performance

Real Options "in" projects

- These create options, by designing technical system
- They require understanding of technology
- Example: Communications Satellites
  - Designers can create options for expansion of capacity by way they configure original satellites and their constellation
  - Option requires technical intervention in order to create and to exercise
- Differs from other "real" Options because
  - Special effort needed to model feasible flexibility within system itself

Choosing Valuation Method in Practice

- Compare efforts at two companies
  - Merck: used financial approach to options
  - Kodak: used decision analysis
- Examine Factors that influence Choice
  - Type of Information available
  - Structure of Industry, possibility of comparable situations
  - People in organization doing analysis: engineers or finance?
- What is goal?
  - Judgement: finding a precise price to pay?
  - Choice : Are we better off with option than without?
- Finding:
  - Valuation is a balance between "precision" and "practicality"

Real Options at Merck

- Merck values real options using financial framework
  - Black-Scholes formula
  - Other models for support (monte-carlo simulation)
  - Applies to variety of areas: R&D, acquisitions, etc...
- Example: Gamma project
  - Options analysis used to value development contract with a biotech company
  - Investment in R&D creates option for future scale-up and commercialization
  - Similar to motivation example in Options Concepts lecture: Investment contract with start-up can be dropped… or company can be bought out research phase successful

Analysis for Merck Case

- Project Gamma as a call option
- Can be exercised after development phase (about two years after time zero) when prospects are more clear
- Valuation procedure
  - Value of project = Capitalized value of projected cash flows acted as underlying asset (stock equivalent)
  - This is equivalent to projected stock market price
  - Volatility based on comparable companies in biotech databas
  - varied between 40-60 percent as part of sensitivity analysis
  - Cost of manufacturing scale-up is strike (exercise) price
  - Time before expiration was varied between 2 to 4 years
  - Risk-free rate based on U.S. Treasuries

Real Options at Kodak

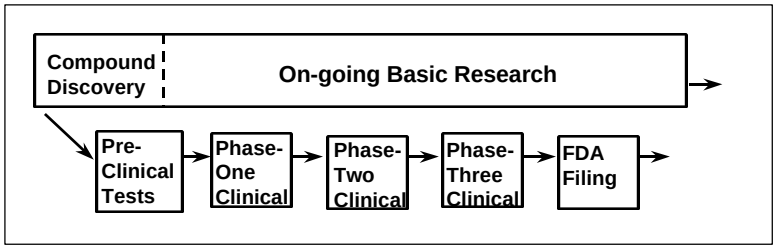
- Kodak has valued real options using decision analysis
  - Understanding financial frameworks informs process
  - Occasionally, might use more strict financial framework
- Example: color printer project
  - R&D project faces technical and market uncertainties
  - Must decide separately if R&D and commercialization are worth pursuing
  - R&D creates option to commercialize
  - Analysis done in R&D/Systems Engineering group

Analysis for Kodak Case

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

Drivers of Choice of Method: Business Structure

- **Merck**
  - Pharmaceutical development process highly regulated by FDA
  - All go through same path to market (10 years))
  - 1000's of candidate drugs provide statistical database
  - Reasonable to speak in terms of an average project and estimate volatility



Drivers of Choice of Method: Business Structure

- **Kodak**
  - Involved in multiple businesses: film, imaging, printing, etc.
  - Product development processes might be similar, but do vary
  - Hard to think of what an average project might be
  - No comparable data available publicly, either from FDA or from range of start-ups in imaging industry (there aren't any)
  - Data needed for a financial analysis not available

Drivers of Choice of Method: 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**
  - **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**
  - **Difficult to assemble relevant databases**
  - **Projects might vary widely from averages anyway**

Goals of 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)**
- **Selection of Valuation method based on ease of implementation**
  - **Merck finance dept: uses financial models, has needed data**
  - **Kodak R&D dept: uses decision analysis as seems useful**
- **Hard to argue which approach is better…**
  - **Objectives, circumstances differ substantially**
  - **Sensitivity analysis helps to address remaining uncertainties**

Real and Financial Options Differ

- Real options may not refer to traded assets
  - The option to change manufacturing process (use a different fuel) rather than to buy a stock
- Thus, possibly no obvious history to value of asset
  - Stocks have a long record of average price and variability
- Real substitutes for this history not obvious
  - If real option concerns traded commodities (such as fuels) a suitable history may be available
  - In other cases it may be quite impractical
- Financial Methods of Valuing Options need adjustment when applied to real systems

Points to Consider in Selecting Valuation Method

- Options theory concerned with pricing
- Decision analysis concerned with developing strategy
- Must consider needs
  - Valuation according to strict finance perspective
  - Setting guidelines for strategic planning
- Should also consider
  - level of required effort
  - ease of use -- by developers and clients of analysis
- Beware of false sense of precision

Also Keep in Mind...

- Conditions when financial models work well
  - One or a few uncertainty variables
  - These have an established market price history
- Conditions when decision analysis works well
  - Likelihood, timing of critical uncertainties and decisions understood
  - Information sources focused on individual project
  - Variables without an established price history are important
- Real options approaches can be more compact
  - Decision trees rapidly become bushy
- Significant value in the mind-set
  - Approximate values can be a vast improvement

Summary

- Real options encountered in projects and daily life, and are 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)
- Finance Models
  - Are Correct Theoretically
  - May be Differ to apply
  - Precision may be illusory, since data is not fully appropriate
- Decision analysis
  - Not Correct if Replicating portfolio can be established
  - Make often be most practical, however
- Choice of Valuation depends on Circumstances

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