

Real Options

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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

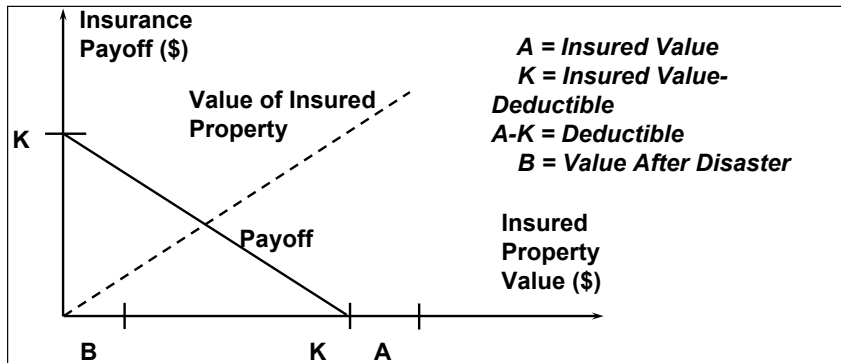
- **Examples:**
 - **Lease car or equipment with option to buy**
 - Person with lease decides at end of contract
 - Action is to buy at end of lease (or to walk away)
 - Lease period defined up-front (typically 2-3 years)
 - Purchase price defined in lease contract
 - **Flexible manufacturing processes**
 - 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

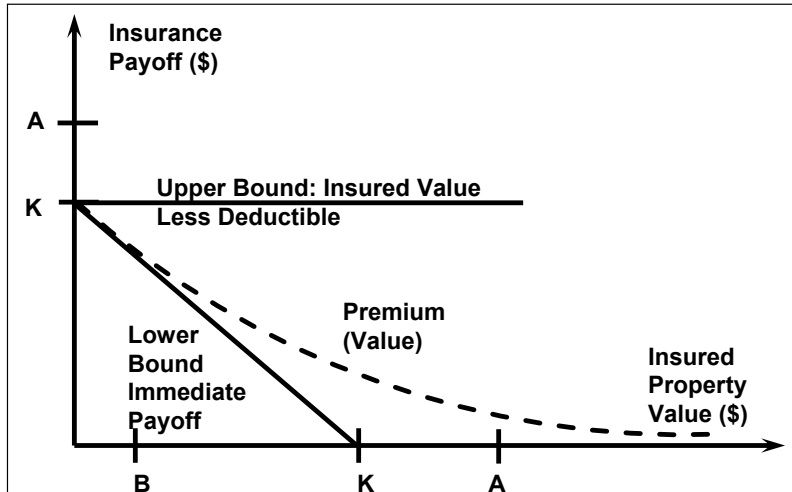
- Maximum payoff is insured value minus deductible
- Minimum payoff is zero
- Payoff resembles put option



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: $\text{Max} [\text{immediate investment}, \text{waiting}, 0]$
- **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: $\text{Max} [\text{status quo}, \text{expanded project}]$
- **Restart Temporarily Closed Operations**
 - Similar to waiting to invest or expand (a special case)
 - Choice based on: $\text{Max} [\text{remain closed}, \text{re-open}]$

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)

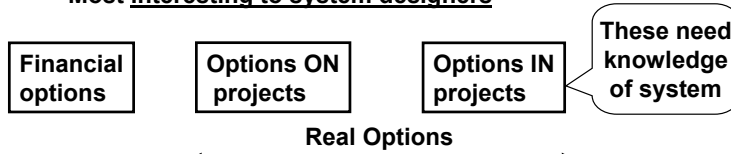
- **Switching Between Modes of Operation (example: dual fuel burner case)**

- 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

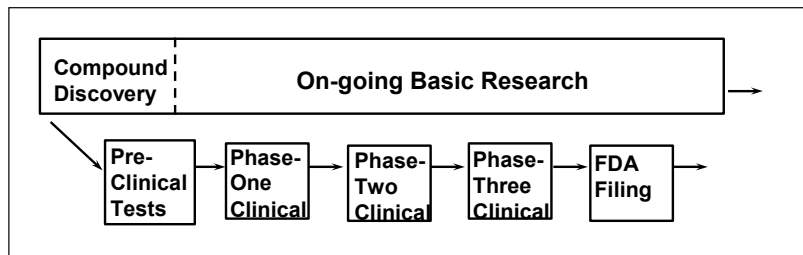
Analysis for Kodak Case

- **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 Difficult 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**

Some References

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