Use of Simulation in Valuation

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Outline for today

- **Context: Approaches to Valuation**
- **Simulation Procedures**
- **Example of Use: Antamina Mine**
  - **Separate Slide show**

Context for Option Valuations

- **Many Approaches to Valuation, differing by way they Model and Value Uncertainty**
- **Presentation so far of Standard Choices**
  - **DCF, Decision Analysis, Black-Scholes etc**
- **Beginning Now: New, pragmatic approaches**
  - **Use of Simulation (Antamina Mine)**
  - **Hybrid Analysis (Neely, auto case)**
  - **Non-Recombinant Lattices (Wang)**
  - **Locating Best Options – Variations on DSM**
  - **Oil Field Applications (Hassan, Lin)**
  - **New Analytic Methods (Cardin, Quispez-Asin)**

Context for Valuations -- Table

Modeling of Uncertainty	None	CAPM	Hybrid	Replicating Portfolio
Simulation				Antamina Example
Non-Recombi -nant Lattice				Wang Thesis
GBM		Homework Assignment		Black-S.
Lattice		Homework Assignment		Binomial
Subjective Probabilities	Garage Case	Decision Analysis	Neely	
None	DCF			

Valuation of Uncertainty

Context for Valuations -- Issue

- Given Many Valuation Possibilities…
- The question is: which do we choose?
- At present, no definitive answer …
- A subject of much research
- Rest of Semester presents some recent developments – starting with Simulation

Outline of Simulation Portion

- What is Simulation?
- How is it done?
- General Procedure for using Simulation to Value Options
- Example: Antamina Mine

What is Simulation?

- Replicates outcomes of a probabilistic process (often called “Monte Carlo” simulation)
  - As in “Garage case”
- It provides a way to describe what may occur, in the line of
  - Decision tree, which enables discrete, trend-breaking outcomes
  - Lattice, based on expanding distribution over time
- Can use any variety of irregular distributions

Use of Simulation is New

- Recent software makes simulation feasible
  - Simple example: Excel Add-in (see ESD 70)
  - Expensive, slick example: Crystal Ball
- 1000’s of repetitions in seconds
- Often, model of consequences simple, for example, spreadsheet modeling profits
  - Example: Garage Case
- More Complicated: See Antamina case

Requirements for Simulation

- **Distributions for Key parameters**
  - **May be observed, assumed, estimated, or guessed**
- **Examples:**
  - **Observed: Rainfall, river flows over years**
  - **Assumed: Market data as GBM (price of metal)**
  - **Estimated: Technical Cost Models (of mine ops)**
  - **Guessed: Judgment (ore quantity, quality)**

Simulation Process Consists of:

1. **Having a model of system (Ex: NPV of mining)**
2. **Defining the distributions of key parameters (Ex: ore quantities, price of metal)**
3. **Sampling a process (Ex: the distribution of the quality of ore in a mine), to...**
4. **Obtain a value of a parameter (Ex: ore quality)**
5. **Calculating the consequences of that factor (Ex: the profit from that mine)**
6. **Repeating 1000's of times, to get probability distribution of consequence (Ex: the profit)**
7. **Calculating EV(NPV) and plotting Value at Risk and Gain (VARG) curve**

Option Value by Simulation

- **Step 1: Get distribution of consequences (Ex: profitability of Mine) and expected NPV**
- **Step 2: Assume option exercised only in favorable circumstances, thus drop unprofitable outcomes from distribution**
  => revised NPV distribution, EV(NPV)
- **Step 3: Value of Option is difference**

Range for Option Value by Simulation

- **Both Market and Technical Uncertainties**
  - **This is a most important feature for real options**
  - **Standard financial approach ignores technical uncertainties of any project – why is this? Reasoning is that investors can diversify among projects and so should ignore project risks**
  - **Project owners however cannot ignore!**
- **Both types of real options**
  - **"on" projects, where technology is a "black box"**
  - **"in" projects, with options designed into project**

Antamina Mine Example

- General Context
  - Peru government wanted to develop a mine
  - Mine had uncertain quality and quantity of ore
  - Step 1: explore geology, topography for access
  - Step 2: decide to develop and spend 3 years on building facilities before getting profits in Year 6
- Government plan
  - Required bidding on 2-stage process
  - Companies must bid for right to explore and must decide on development in 2 years
  - Big penalty for not developing (why?)

Antamina Mine -- Options

- Option "on" project
  - Winning Company has "right, not obligation" to abandon mine in 2 years ➔ "European" put
  - Option Cost = Price to Peru + Exploration Costs
  - Strike Price = Costs forfeited to Peru
- Options "in" project
  - Technical staff can create Options "in" system
  - Ex: build up port during 2 years of exploration, to provide "right, not obligation" to expedite development in only 2 years – and thus advance revenue stream by 1 year and increase NPV

Antamina Mine Simulation

- System Model: NPV of Profit as function of:
  - ore quality, quantity
  - cost of mining
  - value of metals (mostly copper, zinc and "moly")
- Distributions for Key parameters
  - Assumed: Market data as GBM (lattice evolution from current price of metal)
  - Estimated: Technical Cost Models (of mine ops)
  - Guessed: Expert Judgment, revised of exploration of ore quantity, quality (as in a decision tree)

Antamina Mine Valuation

- Assumed operators could "lock in" price for metal by long-term contracts over life of mine
  - Probably not possible in fact. However, it is necessary assumption to know value of ore to use as basis for valuing NPV of mine over its life
- Value of "on" Option = EV(all positive NPV) – EV(project without option to abandon)
- Value of "in" Option = further improvements in NPV due to flexibility provided
- See special Antamina slide show

Take-Aways

- **Simulation is a useful way to represent pdfs of outcomes that will define value of option**
  - **Computationally efficient**
- **Can deal with all kinds of uncertainties**
  - **Contrast to B-S, lattice techniques**
- **Relatively easy to explain to decision-makers**
  - **No complicated math, no "replicating portfolio", no confusing trees or "messy bushes"**

CAN BE A VERY GOOD APPROACH