Applications of Real Options

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Status of Real Options

- Field is "hot" -- topic is new and promising
- Many Issues surround application of real options, especially "in" projects
- These are subject of much current research, SM and PhD theses
- Your participation invited!

General Research Objectives

GENERAL: To Determine how to Apply Real Options Effectively to Engineering Systems

DETAILED: To Modify general approach as needed for domains, and to develop model applications

Level of Analysis	Application Domain				
	R & D Choice	Water Supply	Supply Chain	Hydro-power	Etc, Etc
General					
Detailed					

Specific Research Objective

Which Analytic Approach Best in Specific Cases?

		CAPITAL BUDGETING TECHNIQUES		
		Net Present Value	Decision Analysis	Real Options Analysis
OBJECTIVE FUNCTION	Point Estimate of Project Value			
	Obtain Strategy			
	Price Flexibility			

Some Implementation Issues

- System Modeling
  - Making models suitable for options analysis
  - Ex: Satellite Communications (complexity) ; River Basin Development (stochastic optimization)
- Determination of Useful Options
  - What can be done “in” projects, Which Best?
- Choice of Approach
  - Which best for Users? For which objectives?

Some Examples

- Satellite Communications
  - Prof. Olivier de Weck, Mathieu Chaize
- Bogota Water Supply
  - Natalia Ramirez, R. de Neufville
  - Best Thesis prize in TPP, 2002
- Hydropower in China
  - Tao Wang, R. de Neufville

Satellite Communications

- Satellite research team has developed system model Life Cycle Cost vs Capacity (as presented earlier in class)
- Now reframing issue:
  - From: Minimize cost for specified capacity
  - To: Min Cost to achieve capacity -- if needed
- Implies use of options to reach capacity if needed, otherwise avoid extra cost
- Following slides derived from M. Chaize

Presentation of the problem

- The idea is to deploy a constellation of communication satellites for a lifetime of 15 years.
- Initial demand estimated as 70,000 subscribers
- Ultimate demand might be up to 1 million subscribers

A Simple Base Case

- To meet requirements, consider 3 types of architectures:
  - A is fixed and optimal for a capacity of 1 million users
  - B = (B1, B2, B3) is a constellation that can be upgraded twice with orbital reconfigurations. It was selected such that B3 = A
  - C = (C1, C2, C3) is another reconfigurable system with an initial capacity Cap(C1) around 70,000 and a potential capacity Cap(C3) above 1 million
- Full analysis would consider "all" architectures

Engineering Systems Analysis for Design
Massachusetts Institute of Technology
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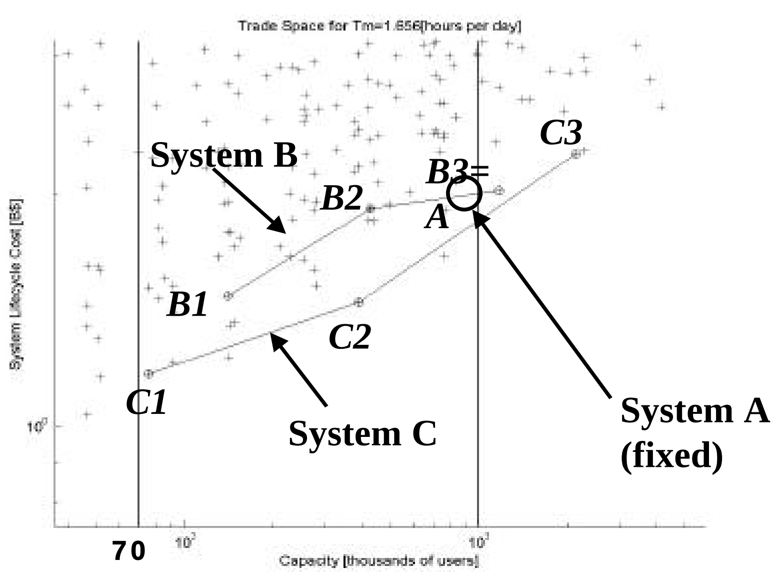
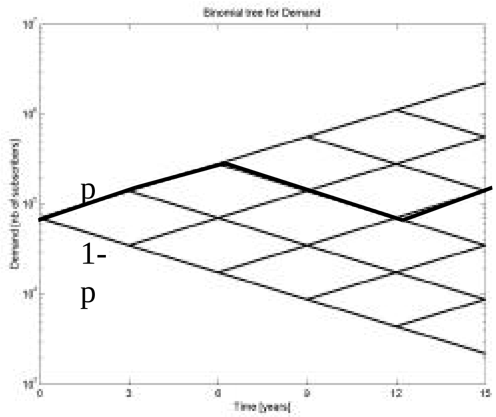
Options -- Real Applications
Slide 9 of 20

Representation of the architectures



Demand Model: binomial tree

- **We have:**
  - **Volatility = 40% per year**
  - **Drift rate = 10% per year**
  - **u = 2; d = 0.5; q = 0.57**
- **To calculate the costs, we consider paths in the binomial tree (for example: red line)**



Calculations

- **Calculate expected value for each path in the binomial tree and each system A, B and C**
  - **Note: We must consider paths in the binomial tree. We have to distinguish up and down, from down and up (this differs from standard options analysis!)**
- **Results, in terms of system cost:**
  - **System A: 2.01 $B**
  - **System B: 1.81 $B (~10% less than A)**
  - **System C: 1.66 $B (~18% less than A)**
- **Options => $ 350 million improvement !!!**

Future Work

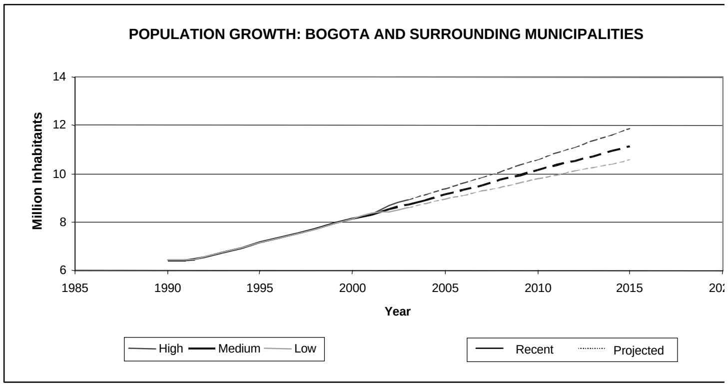
- **Base Case demonstrates that designing options into system worthwhile**
- **Need to explore how to define**
  - **distribution of system profits = (revenues - costs)**
  - **optimum path for any maximum capacity**
  - **optimum choice of maximum capacity**
  - **sensitivity analysis to assumptions**
  - **overall best system architecture**

Bogota Water Supply

- **Great additions to capacity needed**
  - **Increasing population (2 to 3% annually)**
  - **Growth in use per person**
- **Large economies of scale**
  - **impetus to large immediate additions**
  - **but, possibility of unneeded capacity**
- **Close political review**
  - **Water prices justified by increased costs**
  - **Thus close supervision of capacity increases**

Growth of Bogota

Over 8 million in 2000, 10 to 12 million by 2015



Research Topics

- **Can we do an options analysis for this civil engineering / water supply system?**
  - **Yes -- Needs careful thinking about nature of asset**
- **Which is better approach options value?**
  - **Traditional Net present value?**
  - **Decision analysis?**
  - **Financial Options Analysis?**

Which method best?

- We have 3 criteria for "best" method:
  - Theory: correctness
  - Practicality: Ease of use
  - Political: Can it be understood by reviewers?
- Each method justified "real options" design
  - Differed by value set on this design
- Decision Analysis preferred overall
  - Engineers understand it
  - Can be explained to review board

Summary evaluation of methods

OBJECTIVE FUNCTION		CAPITAL BUDGETING TECHNIQUES		
		Net Present Value	Decision Analysis	Real Options Analysis
OBJECTIVE FUNCTION	Point Estimate of Project Value	YES (US$126M)	YES (US$126M)	NOT CLEAR
	Obtain Strategy	NO	YES	NO
	Price Flexibility	NO	YES (US$248M)	YES (US$93M)

Generalization of Findings

Hypothesis (to be tested): Best Method depends on:
-- objective of analysis (Strategy or Price)
-- price data on asset (market, proxy or none)

		DATA QUALITY (INFORMATION FOR UNDERLYING ASSET)		
		Traded	Not Traded, but Market Value Proxy Available	No Market Info Available
OBJECTIVE FUNCTION	Obtain Strategy	ROA (Oil Field)	ROA/DA (Toll Road)	DA (Water Utility)
	Price Flexibility	ROA (Electrical Utility)	ROA (Toll Road)	DA (Water Utility)

Hydropower in China

- **Hydropower big in China**
  - huge potential; biggest dams (Erfan, 3 Gorges)
- **Great uncertainties**
  - growth rate; price of power
- **World Best design practice is inadequate**
  - No consideration of risks, let alone of options
  - Erfan is technical success, financial failure
- **Challenge: to develop real options methodology for waters resources projects**
  - Tao Wang next describes his thesis