Flexibility Concepts

ESD.71 Recitation
October 7, 2004
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Outline

• Part I
  – Optimal plant capacity expansion HW

• Part II
  – Examples of flexibility from my research on building system design
“Flaw of Averages”
\[ \text{EV}[F(x)] \text{ is not equal to } F[\text{EV}(x)] \]

- Flexibility has value.

- How do I design flexibility into a system?
  - As a first step, identify (potential) changes in future conditions
Hierarchy for Learning about Flexibility

1. Single large initial investment
2. Fixed expansion plan
3. Dynamic expansion plan
4. Dynamic expansion plan under uncertainty
Optimal Plant Capacity Expansion

Part I

• Take a step back to consider the concepts this problem is demonstrating:

  1. *What is the right rate to expand the plant?*
     - *Tradeoff between discount rate and economies of scale*
  2. *Flaw of averages*

→ *Will need to use data tables in this exercise*
Variables

Inputs
- \( r \)  discount rate
- \( a \)  economies of scale
- \( x \)  cycle time
- \( D \)  demand (assume linear growth rate)

Calculations
- \( c \)  capacity addition  \( c = xD \)
- \( F(c) \)  cost of capacity addition  \( F(c) = kc^a \)
- \( \text{NPV} \) (of costs)  \( \text{NPV} = \text{sum} [F(c_t)(1+r)^{-t}] \)

How do you identify the optimal cycle time?

Action 4 from Base Case HW
Convince yourself of the “Flaw of Averages” (I)

Part I
Convince yourself of the “Flaw of Averages” (II)

The range of future demand is 2-8 units/yr/yr. The mean of this range is 5 units/yr/yr.

\[
\text{NPV}(D=8) + \text{NPV}(D=2) \neq \frac{\text{NPV}(D=5)}{2}
\]

Discussion Ques. 3 from Base Case HW
Now given step function for demand growth, what will you do?

Part I

Graph 1: Demand growth rate vs time

Actions 1 & 2 and Discussion Ques. 1 from Flexibility HW
Part II: Flexibility in Building Design
Corporate Real Estate Example

- Drivers of space changes
  - Mergers
  - Business unit needs (growth and decline)
  - Maintain contemporary image
Framework to Address Uncertainty

Identify uncertainties

Design flexibility into the system

Develop a model to value the flexibility

Interpret results: is cost of obtaining flexibility warranted by its value?
Relevant Uncertainties

- When won’t the lab space be needed?
- What will be the new need?
- What might the alternatives to renovating be?
- How much of the space will not be needed?
- What if want to change again?
Design Flexibility into the System

Renovation Cost

$25 /SF  $50/SF  $125/SF

Decreasing Flexibility
Part II

Developing a Model

How much should I invest in the flexibility to change the use of the space?

- Office type space is valued by the market.
  - Use market rate of rent for office space to value a conversion to office space.

- Can use a theoretical model for market uncertainties.
  - Binomial-lattice model.

- Use simulation to model uncertainty in timing and amount of space need.
Interpret Results

• It is worth $___ today to invest in a flexible design that will allow us to renovate the space for $___ in the future.

• Compare the cost estimates of the physical designs to the valuation results
  – Is it wise to invest in the flexible design?

• Other decision factors
  – Architectural critique
  – Environmental, health, and safety evaluation
Conclusion

- "Flaw of Averages"
  
  \[ \text{EV}[F(x)] \text{ is not equal to } F[\text{EV}(x)] \]
  
  for nonlinear \( F(x) \)

- Flexibility has value.

- How do I design flexibility into a system?
  - As a first step, identify uncertainties.
  - As seen in building example, can reduce the risk of owning a sub-par building through flexible design.