1.011 Project Evaluation
Dealing with Risks & Uncertainty

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1. Definitions
2. Techniques
3. Examples

"Make Uncertainty Explicit"

(Principle 6, Sullivan et al, Engineering Economy, p. 7)

- Understand the uncertainties and the risks
- Seek protection against the most serious risk
- Use discount rates that are suitable for the risks evident for a particular project
  - Higher discount rates for riskier projects

Uncertainty

- We cannot predict the future, and we may not even have good estimates of probabilities of possible outcomes
  - Variations about the norm
  - Changes in trends
  - "New Facts"
- Projects create new demands - and we can't always refer to past experience

Risks

- Risks refer to the possibility that something will go wrong. For example:
  - Construction risks(unable to construct on time and within budget because of technical or organizational problems)
  - Competitive risks (loss of market to better,earlier, or larger projects similar to or substituting for your project)
  - Financial risks (changes in interest rates ,exchange rates, credit limits that affect our ability to raise sufficient funds for project; changes in cash flows that affect ability to mortgage payment)
  - Political risks (changes in government or in regulations that limit our ability to complete, open, or receive payment for our project)

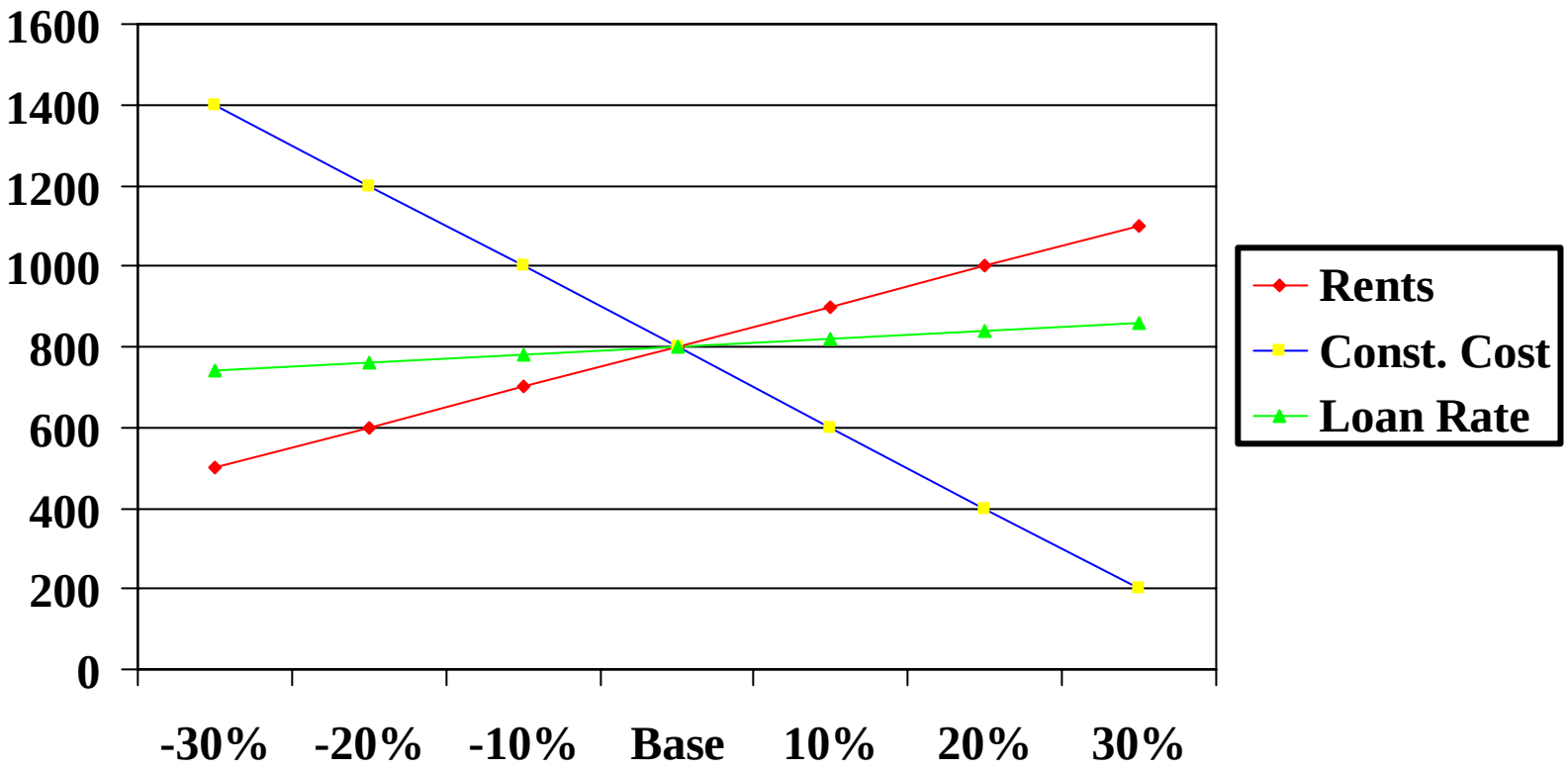
Methods

- Methods driven by the analysis
  - Sensitivity Analysis
  - Probabilistic Analysis
  - Monte Carlo Simulation
- Methods driven by the structure
  - Key drivers
  - Scenarios

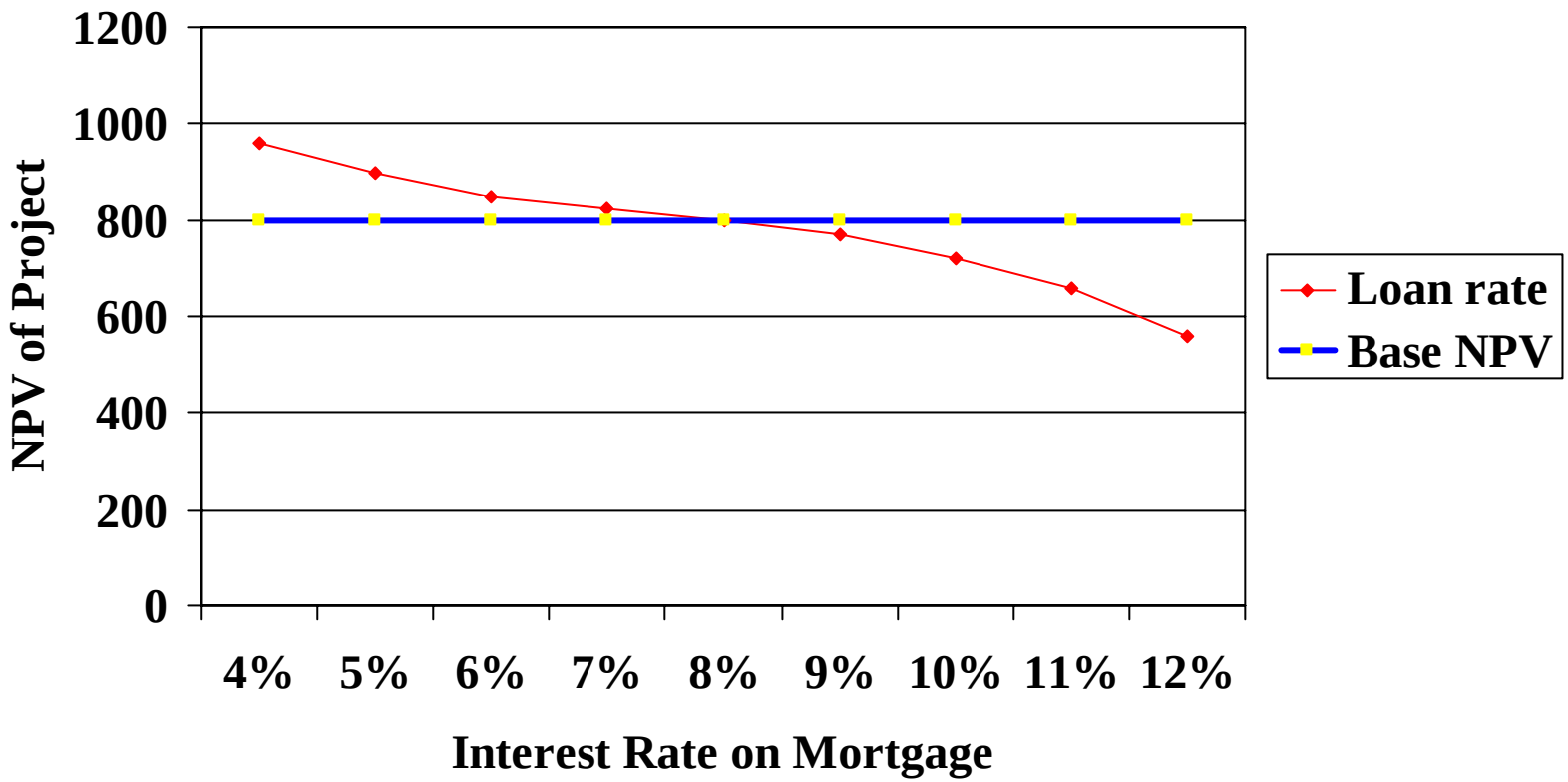
Sensitivity Analysis

- Systematic analysis of the effects of changes in one or more variable on our results and our choice of an alternative
  - Cost factors: unit costs, discount rates, process speed
  - Benefit factors: prices, demand, external impacts
- Key choices
  - What is our base case?
    - Best estimate of all factors
  - What factors to vary? by how much?
    - Those with the greatest uncertainty and those related to known risks
    - Vary over likely range of options

Sensitivity Analysis: "Spiderplot"
($2 billion building with NPV of $800 Million)



Sensitivity Analysis:
Using a More Realistic Range for Varying a Single Factor
($2 billion building with NPV of $800 Million)



Sensitivity Analysis

"In engineering economy studies, sensitivity analysis is a general nonprobabilistic methodology, readily available, to provide information about the potential impact of uncertainty in selected factor estimates. Its routine use is fundamental to developing economic information useful in the decision process"

Probabilistic Analysis

- Treat the key factors as random variables (continuous or discrete)
- Develop expressions for key performance measures as functions of the random variables
- Calculate the probability that the results of the project will be unacceptable

Probabilistic Analysis: Difficulties

- We generally don't know the probabilities
- The math gets complicated very quickly
- The design process is more related to "possibilities" than to "probabilities"

Scenarios

- A "scenario" is a set of internally consistent assumptions that together provide a vision of a "possible" future within which our project will be implemented
  - Broader than sensitvity analysis
  - For example: Optimistic/Most Likely/Pessimistic
- Elements of a Scenario - the factors that we believe are important to our project that we wil vary across scenarios. For example:
  - General economic conditions
  - Response of competitors to our project
  - Construction prices

Steps for Developing Scenarios

Peter Schwartz, "Art of the Long View"

- Identify the focal issue or decision
- Identify key local forces
- Identify key external forces
- Rank by importance and uncertainty
- Select scenarios defined by drivers
- Flesh out the scenarios
- Implications
- Identify and monitor leading indicators

Creating and Using Scenarios

("Mobasheri, Orren, and Sioshansi, "Scenario Planning at Southern California Edison", Interfaces 19: Sept-Oct 1989, pp. 31-34)

- "Futility of plans based upon rigid forecasts"
- "Focuses on what might happen, or can go wrong, and how to deal with it"
- Developed 45 scenarios in12 clusters related to demand for peak power: "representative of all plausible scenarios that might be constructed"
- Address strategic concerns for each scenario
- Seek strategies to "eliminate or mitigate the consequences of bad outcomes"
- "No attempt to assess probabilities"

Probabilistic Risk Assessment

- Problem: how to deal with risks related to natural disasters or unusual events (earthquakes, fires, accidents)
- Assess Risk = PROB x CON
  - PROB = Probability of event
  - CON = Expected consequences of event
- Assess cost ΔC of reducing risks
- Compare incremental cost to incremental risk
  - If ΔC < reduction in risk, then it is worth adding the extra cost
  - There may be many effective ways of reducing risks

Probabilistic Risk Assessment: Reducing Highway Risks

- Reduce probability of accidents
  - Licensing requirements
  - Enforcement (speed, drunk driving, etc)
  - Highway geometry
  - Highway maintenance
  - Free coffee at rest stops
- Reduce severity of accidents
  - Seatbelts
  - Automobile construction
  - Roadside barriers & removal of obstacles

Probabilistic Risk Assessment: Reducing Risks of Flooding

- Probability of floods
  - Hydrological records (100-year flood)
- Consequences of floods
  - Historical records (damage & fatalities associated with N-year floods)
  - Predictions of future damages
- Options
  - Dams & levees
  - Limit development in flood plain
  - Build to withstand floods

Probabilistic Risk Assessment: Evaluating Flood Control Projects

- Estimate costs of options
  - Convert to equivalent future annual cost
- Estimate expected costs of floods, for each option
  - Convert consequences of N-year floods into expected consequences per year
- Compare reduction in annual consequences to equivalent annual cost of project

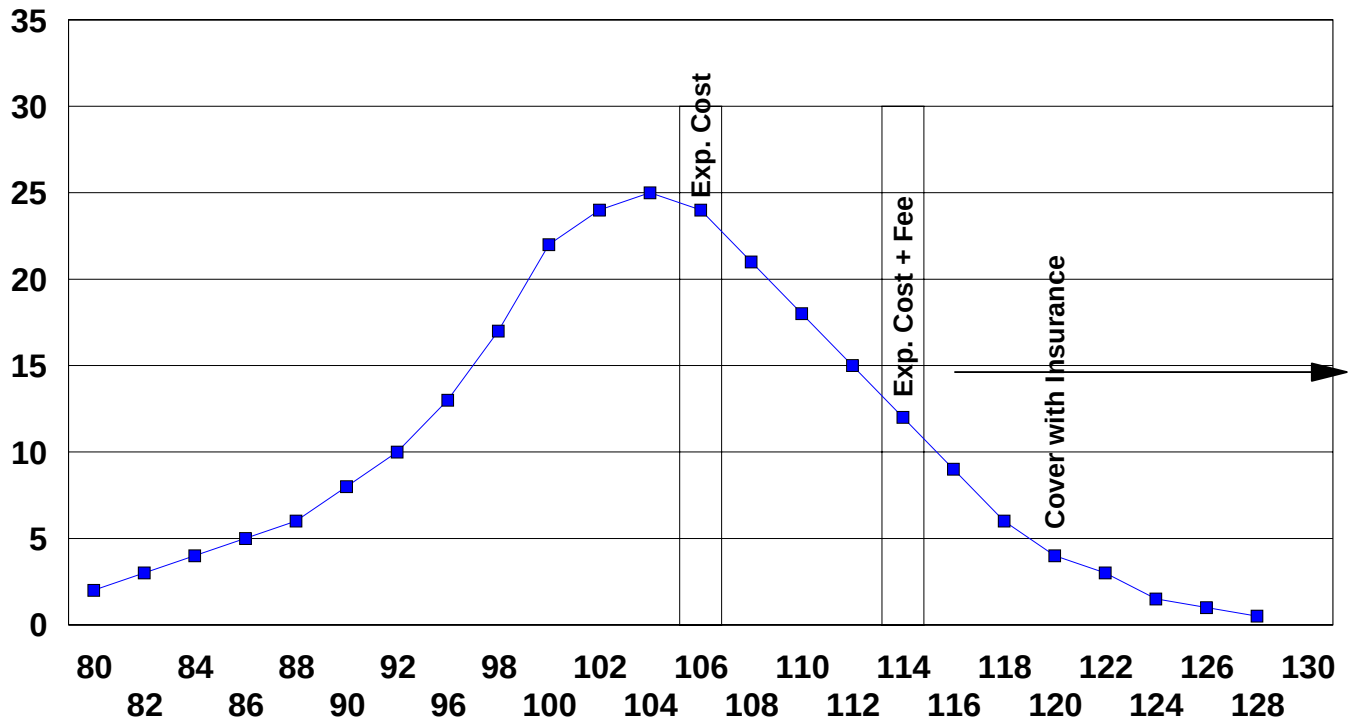
Protection Against Project Risks

- Failure to meet budget & time table
  - Studies, site surveys
  - Penalty clauses in subcontracts
  - "Cost Plus" rather than "Fixed Price" contract
- Failure to meet revenue targets
  - Studies and surveys
  - Pricing & staging options
- Natural disaster; construction accidents
  - Insurance
  - Safety plan - **WHEN** to work; **HOW** to work
- Bankruptcy
  - Minimal leveraging; loan guarantees
- Government interference
  - Partnerships with government or local firms

Risks Are Shared Among the Actors Involved in a Project

- Are MY risks commensurate with MY potential benefits
- Can I include sufficient time in the work schedule to cover the expected range of delays and a sufficient amount in my budget to cover the expected range of cost variation?
- Can I get insurance to limit my liability for the worst things that might occur?
- Can I negotiate a better deal?

Bidding on a Project:
Include a "Margin of Error"



Staging

- Break the project into several stages that can be implemented if and when demand warrants
  - May lead to higher construction consts for the project if all stages are eventually build
  - Added flexibility reduces risks that insufficient demand will lead to financial problems
- Examples
  - Build one tower where there is room for two
  - Buy options for additional land
  - Build a house, but don't finish the basement or the attic

Public Role

- Loan guarantees
  - Reduce interest rates for private sector
- Partnerships
  - Ease burden of dealing with regulations
- Contract for services (e.g. for commuter rail)
  - Contractor provides service; agency absorbs risks related to demand and revenues
- Exclusive franchises (e.g. for highway)
  - Limit competition