L12 APSC221 - Risk & Uncertainty

Overview

- Economic analysis often assumes all future cash flows (CFs) occur with certainty.
- In reality, projects face risks and uncertainties.
- Qualitative methods help understand and manage these uncertainties.

Key Points

- Sensitivity analysis and break-even analysis address uncertainty (no probabilities).
- Decision trees address risk (with probabilities).
- Each method helps inform better decision-making under imperfect information.

Brief Description

- **Sensitivity Analysis:** Examines how changes in one parameter affect project outcomes.
- **Break-even Analysis:** Identifies parameter values where a project just meets a threshold.
- **Decision Trees:** Models sequential decisions and chance events, incorporating probabilities.

Intuition

Why It Matters

- Real-world projects rarely unfold exactly as planned.
- Understanding which variables most affect outcomes helps prioritize attention and resources.

Underlying Logic

- Sensitivity and break-even analyses reveal which assumptions are most critical.
- Decision trees break complex, uncertain decisions into manageable steps.

Analogies

- Sensitivity analysis is like testing how a car's speed changes with different amounts of fuel.
- Break-even analysis is like finding the minimum number of tickets you must sell to cover concert costs.
- Decision trees are like flowcharts for "choose your own adventure" stories, but with probabilities.

Options/Frameworks

1. Sensitivity Analysis

- **Approach:** Change one parameter at a time, observe effect on outcome (e.g., Present Worth (PW), Annual Cost (AC)).
- **Tools:** Sensitivity graphs (plot outcome vs. parameter).
- **Pros:** Simple, highlights key variables.
- **Cons:** Ignores interdependencies, only two variables at a time.

2. Break-even Analysis

- **Approach:** Vary a parameter to find the value where the outcome meets a threshold (e.g., PW = $10,000).
- **Pros:** Answers specific "what if" questions, useful for scenario planning.
- **Cons:** Cannot capture variable interdependencies.

3. Decision Trees

- **Approach:** Map out decisions and chance events in sequence, assign probabilities, calculate expected values.
- **Components:**
  - *Decision node (square):* Choice to be made.
  - *Chance node (circle):* Uncertain event.
  - *Branches (lines):* Sequence of decisions/events.
  - *Leaves:* Final outcomes/payoffs.
- **Pros:** Handles complex, multi-stage decisions; incorporates risk.
- **Cons:** Can become complex; requires probability estimates.

Formulas

- **Expected Value of Random Variable:**

$$E(X) = \Sigma x_i p(x_i)$$

  - x_i: Possible outcome
  - $p(x_i)$: Probability of outcome x_i
  - *Example:* If PW can be $5k$ (20%), $10k$ (50%), $15k$ (30%):
    $E(PW) = 0.2 \times 5k + 0.5 \times 10k + 0.3 \times 15k$

Scenarios

- *Sensitivity Graph:* Vary MARR (Minimum Attractive Rate of Return) to see how PW changes.
- *Break-even:* Find utility cost where PW = $10,000.
- *Decision Tree:* Choose between Machine A and B, each with different probabilities for high/medium/low returns.

Assumptions & Common Pitfalls

- **Assumptions:**
  - Sensitivity and break-even analyses assume only one variable changes at a time.
  - Decision trees assume probabilities are known and outcomes are discrete.
- **Pitfalls:**
  - Ignoring variable interdependencies.
  - Overconfidence in estimated probabilities.
  - Oversimplifying complex scenarios.

Summary & Key Takeaways

- **Sensitivity and break-even analyses** help identify critical variables and thresholds under uncertainty (no probabilities).
- **Decision trees** provide a structured way to analyze decisions under risk (with probabilities).
- Use **sensitivity analysis** to prioritize variables for further study.

- Use **break-even analysis** to answer “how much is enough?” questions.
- Use **decision trees** for multi-stage, probabilistic decisions.

When to Use

- Use sensitivity and break-even analyses early in project evaluation to understand uncertainty.
- Use decision trees when decisions depend on sequential events and probabilities are available.