Decision Analysis Models

Outline
- Decision Analysis Models
- Decision Making Under Ignorance and Risk
- Expected Value of Perfect Information
- Global Oil Case
- Decision Trees
- Incorporating New Information
- Expected Value of Sample Information

Decision Analysis Models
- A set of decision alternatives
  - We can choose only one alternative
- A set of possible states of nature
  - We don't know which one will occur in advance
- A set of payoffs
  - Each payoff is associated with an alternative action and a state of nature
  - Value can be monetary or otherwise
Decision Situations

- Certainty
  - Decision maker knows with certainty which state of nature will occur
- Ignorance
  - Decision maker knows all of the several possible states of nature, but does not know the probability of occurrence for any of the states
- Risk
  - Decision maker knows all of the several possible states of nature, and can assign probability of occurrence for each state

Decision Making Under Ignorance - Decision Rules

- LaPlace-Bayes
  - Select alternative with best average payoff
- MaxiMax
  - Select alternative which will provide highest payoff if things turn out for the best
- MaxiMin
  - Select alternative which will provide highest payoff if things turn out for the worst
- MinMax Regret
  - Select an alternative that will minimize the maximum regret

EVPI

- Expected Value Under Imperfect Information (EVUII)
  \[ EVUII = \max(ER) \]
- Expected Value Under Perfect Information (EVUPI)
  \[ EVUPI = \sum \max(R_{ij}) \times P(S_j) \]
- Expected Value of Perfect Information (EVPI) measures how much better we expect we could do if we had the perfect knowledge of the future
  \[ EVPI = EVUPI - EVUII \]
- Expected Regret
Global Oil Case

Step 1: Study the Environment

- Diagnose problem and organize facts:
  - Global Oil has a lease that gives them the right to explore in western Oklahoma.
  - The payoff from drilling will depend on the existence of oil/gas and current market conditions.
  - Prescot Oil offers to buy the lease for a single lump sum.
- Frame management situation:
  - Decision needs to be made to either drill or sell the lease without knowing the actual levels (or existence) of oil/gas deposits.

Step 2: Model Formulation

- Create a selective representation of reality:
  - Estimate cash flows for each decision alternative and state of nature.
  - Estimate probabilities for each state of nature.
- Identify decisions and objectives:
  - Decision: to drill or sell the lease.
  - Objective: maximizing expected return.

Step 3: Model Construction

- Construct the model:
  - Tabular format:
    - Calculate expected return for each of the decisions.
    - Find the maximum expected return and use it to make the decision.
    - Calculate EVPI.
  - Decision tree:
    - Graphical device for analyzing decisions under risk and calculating maximum expected returns.
    - Effective for sequential decision problems.
Global Oil Case

Initial Decision Tree

- Drill
  - Gas Well: $15,000, probability 0.2
  - Oil & Gas: $40,000, probability 0.4
  - Oil Well: $90,000, probability 0.3
  - Dry Well: $200,000, probability 0.1
- Sell the Lease: $12,000

Decision Tree Elements

- Decisions
  - Decision (square) nodes
  - Branches leaving a decision node represent alternative actions
  - The value of a decision node is the maximum of all decision branch values
- Events
  - Event (circular) nodes
  - Branches leaving an event node represent states of nature
  - The value of an event node is the ER of the event branch values

Solving Decision Tree

- Start at the terminal nodes at the end of the tree and work backward
- Fold back the event node by calculating expected return for the event
- Prune (remove) the branches leaving decision node that do not yield the highest expected return
- When completed, the remaining branches will form the sequential decision rules for the problem
Global Oil Case
Initial Tree Solved

Drill

Gas Well

Oil Well

Dry Well

Sell the Lease

Global Oil Case
Terrain Testing

- Terrain configuration is an indicator of the possible gas and oil deposits
- DRI will perform tests for $10,000 to determine the underground formation of the terrain
- The result is going to be one of the following terrain configurations
  - Plate – higher likelihood of a dry well
  - Varied – higher likelihood of gas well
  - Ridge – higher likelihood of oil well

Incorporating New Info

- Global considers conducting a new test in order to make a better decision
  - If the test is done, it is no longer possible to sell the lease
  - Global needs to pay for the test before it knows its outcome
  - Use historical testing results to help assess the probabilities of drilling outcomes given different test results
  - This will also help assess the upper limit on the amount Global should be willing to pay for testing
Calculating Probabilities

- **Prior** probabilities – ex: probability that the well contains gas
- **Reliabilities** – ex: probability that the terrain is varied **given** that the gas was found
- **Marginal** probabilities – ex: probability that the terrain is varied
- **Posterior** probabilities – ex: probability that the well will contain gas **given** the terrain is varied

Global Oil Case

**Final Tree Solved**

Expected Value of Sample Information

- If DRI did the testing for free, the maximum return Global can expect is $57,400
- If Global decides NOT to do the testing, the maximum expected return is $43,000
- Expected Value of Sample Information (EVSI) = $57,000 - $43,000 = $14,400
- EVPI is $23,000
- Testing moderately effective
To Test or Not To Test

- If DRI testing costs $10,000 < EVSI of $14,400 do the test
- Global’s decision sequence
  - Test for the underground terrain structure
  - If terrain plate, do not proceed with drilling
  - If terrain varied or ridge, proceed with drilling
- If DRI testing costs more than EVSI of do not test and proceed with drilling

Bayes Theorem

- State of nature: event
- Information source: predictor
- Prior probabilities – P(event)
  - Initial belief about likelihood of states of nature (subjective)
- Reliabilities – P(predictor|event)
  - Predictive power of the information source
- Marginal probabilities – P(predictor)
  - Likelihood with which predictions occur
- Posterior probabilities – P(event|predictor)
  - Likelihood that state of nature occurs given a particular prediction