

## *Introduction to Decision Analysis*

BU609

The only constant is change,  
The only certainty is uncertainty

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### *Making Smart Choices*

- **P**roblem - frame decision properly
- **O**bjectives - SMART
- **A**lternatives - creative, reasonable
- **C**onsequences - understand
- **T**radeoffs - forces prioritization
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- Uncertainty - assess likelihood, impact
- Risk Tolerance - determine
- Linked Decisions?

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## *Objectives*

- Appreciate how decision analysis can improve business decision making
- Be able to develop Payoff tables and Decision Trees
- Be able to use TreePlan to develop models and to complete sensitivity analysis

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### *Tools and Techniques (ranked in order of usage)*

- Simulation
- Statistics and forecasting
- Linear programming
- Decision analysis
- Queueing analysis
- Integer programming
- Network methods

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## *Key Problem Characteristics*

- Important problem
- Unique
- Non-instantaneous decision required
- Complex
- Uncertainty; therefore **RISK**
- Elsewhere in course will consider decision situations where there is no risk, but decision is very complex

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## *Types of Decision Problems*

- **Certainty** - know which outcome will occur; hence select best alternative
- **Uncertainty** - no probability information available
- **Risk** - probabilities of outcomes (states of nature) are available
- Often faced with a mixture of these!
- Most interesting problems are complex!
- Major difference between 1-shot & continuing, corporate vs personal

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## *Risk*

- Associated with uncertainty; probabilities
- Three dimensions
  - Possible outcomes; Likelihood of each outcome; Impact of each outcome
- Possible responses
  - Avoid/Eliminate, Manage, or Embrace risk
- Major difference between single vs repeated decisions
  - Use risk profile with decision trees, plus sensitivity analysis
  - Use outcome distribution thru simulation

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## *Scoring Model Methodology*

- Identify goal, criteria, alternatives
- Score/Rate each alternative based on each criteria
  - Keep “order of magnitude” the same
- Weight each criteria
- Calculate weighted average for each alternative (sum of scores x weights)
- Consider results, intangibles, other managerial considerations

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## Limitations of Scoring Approach

- Identification of all criteria
  - brainstorming
- Duplication of criteria
  - consolidate like factors
- Determinations of criteria scores & weights
  - often subjective; start with ranking; use main criteria & sub-criteria
- Consistency Check
  - subjective

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## Single Decision, Single Objective, with Risk or Uncertainty

Payoff Tables, Decision Trees

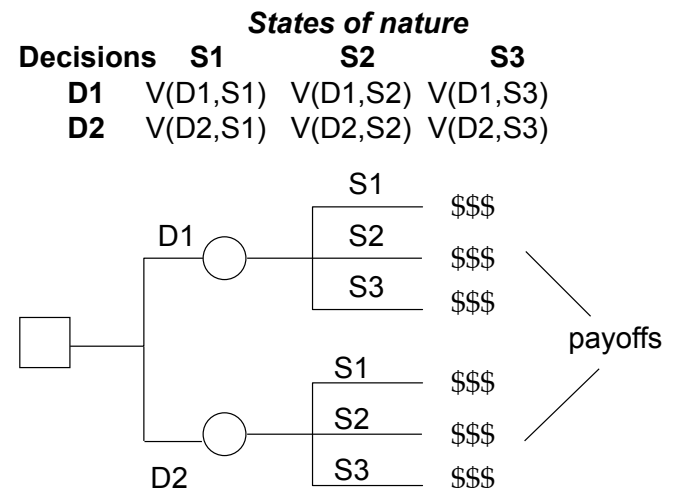
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## Terminology

- **Decision** Alternatives
  - controllable; our choice
- Outcomes, Consequences, **States of nature**
  - future events, uncontrollable
  - define all (mutually exclusive, collectively exhaustive)
- Criteria to evaluate alternatives associated with outcomes (**Payoffs**)
  - $V(D,S)$

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## Payoff Table & Decision Tree



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## Structuring Decision Problems

- Payoff Table
  - table of actions (decisions) vs outcomes (consequences) and payoffs
- Decision Trees
  - chronological representation of problem
  - nodes and branches
  - 2 types of nodes: square = decision, round = outcome
  - payoffs at end of branches

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## Common Approaches (Risk)

- Optimistic
  - Select Decision which is ‘best of the best’; identify best payoff for each decision & take best of these
- Pessimistic
  - Select Decision which is ‘best of the worst’; identify worst payoff for each decision & take best of these
- Equally Likely
  - Sum payoffs for each decision & select best
- Regret Minimization
  - Prepare regret table; select decision which ‘minimizes maximum regret’ (minimax regret)

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## Example

- Profit example

|    | S1    | S2   | S3    |
|----|-------|------|-------|
| D1 | 10000 | 6500 | -4000 |
| D2 | 8000  | 6000 | 1000  |
| D3 | 5000  | 5000 | 5000  |

Optimistic: D1

Pessimistic: D3

Equally Likely: D2 or D3

Minimax Regret: D2

### Regret Table

|    | S1          | S2   | S3          |
|----|-------------|------|-------------|
| D1 | 0           | 0    | <b>9000</b> |
| D2 | 2000        | 500  | <b>4000</b> |
| D3 | <b>5000</b> | 1500 | 0           |

Regret by column (outcome);  
best always 0

Max regret by row; pick least

*Now redo, but payoffs are costs*

## Risk

- Risk implies a given action has more than one possible outcome
- Risk can be subjective or objective
- Impact is important
  - Necessary consideration in risk analysis
- Choices usually possible:
  - avoid, prevent
  - minimize impact
  - Embrace
- Payoff Table Decision shows **Risk Profile**

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## Decisions Under Uncertainty

- Probabilities known for Outcomes (States of Nature)
- Use Expected Value Approach
  - Appropriate when there are many continuing decisions, even though each situation is different
  - Not appropriate for 1-shot “bet the business” decisions
- The decision yielding the **best expected return** is chosen

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## Expected Value (long term avg)

- **Expected value of a decision alternative** is the sum of weighted payoffs for that alternative
- Expected value (EV) of decision alternative  $d_i$  is defined as:

$$EV(d_i) = \sum_{j=1}^N P(s_j) V_{ij}$$

$N$  = the number of states of nature (outcomes)

$P(s_j)$  = the probability of state of nature  $s_j$

$V_{ij}$  = the payoff corresponding to decision alternative  $d_i$  and state of nature  $s_j$

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## Decisions Under Uncertainty

- Expected value approach

|    | S1    | S2   | S3    | EV(D) |
|----|-------|------|-------|-------|
| D1 | 10000 | 6500 | -4000 |       |
| D2 | 8000  | 6000 | 1000  |       |
| D3 | 5000  | 5000 | 5000  |       |

$P(S1)=.6$   $P(S2)=.2$   $P(S3)=.2$

*Calculate for each decision. Which we would choose? Why?*

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## Expected Values

|    | S1<br>(0.6) | S2<br>(0.2) | S3<br>(0.2) | EV(D)       |
|----|-------------|-------------|-------------|-------------|
| D1 | 10000       | 6500        | -4000       | <b>6500</b> |
| D2 | 8000        | 6000        | 1000        | 6200        |
| D3 | 5000        | 5000        | 5000        | 5000        |

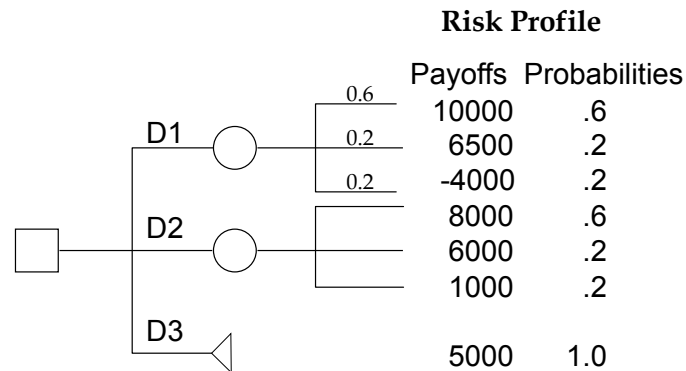
e.g.,  $10000 \cdot 0.6 + 6500 \cdot 0.2 + (-4000) \cdot 0.2 = 6500$

**Risk Profile** of optimal decision:  
10K (p=.6), 6.5K (p=.2), -4K (p=.2)

Remember “Flaw of Averages”

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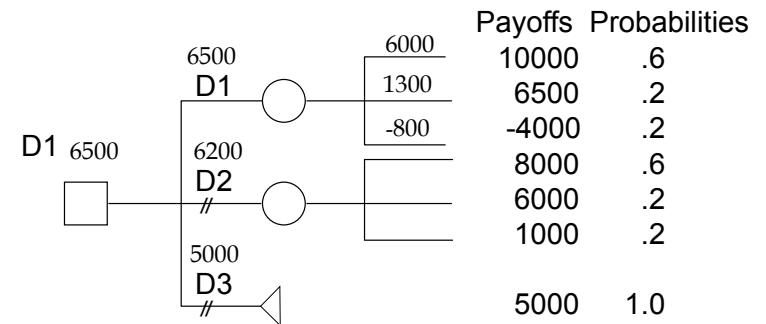
## Decision Tree Approach



**Rollback** to determine decision

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## Decision Tree Rollback



Calculate Expected Value for each path, working back from right (payoffs) to left (decisions); select optimal decision at every decision point

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## Decision Tree Review

- Square = decision, Circle = chance event
- Chronological order, left to right
- Probability above branch, \$ below
- Conditional probabilities
- Payoff at end
- Rollback calculates EV for each “route” and selects best
- Manual calculation fine for small problems; use s/w for larger problems

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## Decision Tree Benefits

- Model decisions efficiently & effectively
  - facilitates understanding
- Formally analyze decisions, clearly laying out goals & options
- Captures a chronological sequence of choices and possible events
- Explain and document your reasoning to others
- Make well-informed decisions

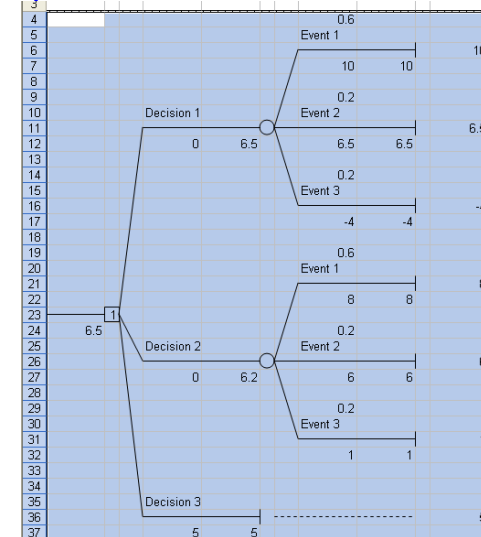
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## TreePlan

- Excel add-in comes with text
  - [www.treeplan.com](http://www.treeplan.com)
- Older trial version available on website
  - Treeplan.xls (see Excel Files)
  - Documentation: Treeplan.doc (see Website)
- Supports building, labeling & rollback of decision trees
- For occasional use, launch Excel and use Excel's File | Open command to load TreePlan.xls; must enable macros
- Use Cut / Paste Special to transfer diagram

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## Example: BU609-7-TreePlan.xls



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## TreePlan Commands

- Ctrl-T: starts new tree (or Tools > Decision Tree from menu bar)
- To expand tree, repeat at node
- Add titles & values (payoffs (below), probabilities (above))
- Choose menu instructions from dialogue boxes
- Easy to learn; just play with it!
- Documentation only 4 pages

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## Linked Decisions: Multiple Decisions over time

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## Structuring Linked Decisions

- More common use of Decision Trees
  - a sequence of decisions (controllable) and events (uncontrollable), over a period of time
- Linked decisions are more complex (initial, future)
- Can be used **quantitatively** or **qualitatively**
- Proctor & Gamble uses for “Real Options” analysis

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## Analyzing Linked Decisions

- Understand basic decision problem
- Identify ways to reduce critical uncertainties
- Identify future decisions linked to basic decision
- Understand relationships in linked decisions
  - get the timing right
  - sketch essence of the decision problem
  - describe consequences at end points
- Decide what to do in basic decision
- Treat later decisions as new decision problems (when time arrives)

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## Exercise, part 1

- Handout: “To Settle or Not to Settle”, part 1
- **Identify:**
  - *decisions*
  - *events*
- **Draw initial decision tree**

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## Non-monetary Tangibles

- \$ equivalent tradeoff
  - “Even swaps”: I’d pay \$x to have this or to avoid it; It would be worth \$x to me
  - Can extend beyond \$\$ swaps (lives, etc.)
- Utility theory
  - Economics approach
- Both approaches are specific to individual and decision situation
- Also works for intangibles (pain, suffering, happiness)

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## *Exercise, part 2*

- Handout: “To Settle or Not to Settle”, part 2
- *Draw final decision tree*
- *What is Expected Value solution?*

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## *Exercise, part 3*

- *What would you have done? Why? How does this reflect personal values and your risk profile? How might the decision be different for the lawyer?*

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## *Keys to Effective Decision Making*

- Work on right decision problem
- Specify your objectives
- Create imaginative alternatives
- Understand the consequences
- Grapple with your tradeoffs
- Clarify your uncertainties
- Think hard about risk tolerance
- Consider linked decisions

Hammond, Keeney, & Raiffa (1999), Smart Choices, HBS Press

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