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Applying Decision Analysis to Real Problems

What is decision analysis?

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What is decision analysis?

A brief overview illustrated by case vignettes

- Decision behaviour, decision theory, decision analysis
- Attributes, criteria, objectives and attribute hierarchies
- Multi-attribute value analysis – brief overview
- Chernobyl: a case study
- Types of uncertainties
- Decision trees and Influence Diagrams
- The decision analytic process
- Group decisions and group dynamics

A little bit about me

Mathematician

→ Decision and risk analyst

→ Chernobyl

→ Mid-life academic crisis!

→ Multi-disciplinary approaches to supporting societal decisions and risk communication

- Nuclear emergency preparedness, response and recovery
- Trawsfynedd decommissioning
- Nuclear sustainability
- Food safety
- Health scares and risks

Decision behaviour, decision theory, decision analysis

Rational Economic Man

- Economists, Philosophers, Mathematicians and others have sought to define what is good decision making.
- Their ideas are embodied in the concept of *Rational Economic Man.*
- Unlimited cognitive powers, optimising his decisions to maximise some concept of utility.
- Normative theory: how he *should* decide.

Behavioural Decision Studies

- Descriptively, the model of Rational Economic Man does not describe actual behaviour
- Many behavioural studies have suggested we are not as good at decision making as we would like to believe.
- Descriptive Decision Science: how we *do* make decisions

Prescriptive Decision Analysis

Normative Decision Theory
provide a model of how people *should* make inferences and decisions

Descriptive Decision Studies
provide models of how people *do* make inferences and decisions

Prescriptive Analyses
seek to guide decision makers towards the ideals encoded by normative theories within the context of a real, often ill-defined problem, mindful of their cognitive characteristics

Attributes, criteria, objectives and multi-attribute value analysis

Value focused thinking

Values are what we care about. As such, values should be the driving force for our decision making. They should be the basis for the time and effort we spend thinking about decisions. But this is not the way it is. It is not even close to the way it is.

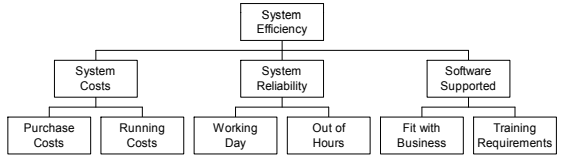
More creative … Keeney (1992)

- alternative focused thinking closes down the mind
- value focus thinking opens it up

Focuses attention on what matters
Teams share common goals

SO DISCUSS VALUES AND OBJECTIVES FIRST

Preference Modelling:
Attribute Hierarchies



Building Hierarchies

- Top down
- Bottom up (brainstorming and gathering)
- Iterative, both top down and bottom up

Checks:

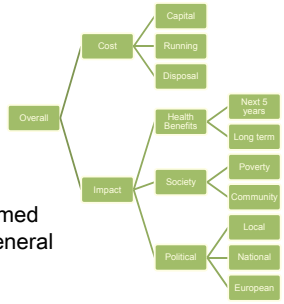
- Why do you prefer this to that?
- Best of all worlds and worst of all worlds

Types of Attribute

- Natural
- Subjective or constructed
- Proxy

An objective is an attribute plus a direction of preference

Not always a vertical tree



Evaluation of a social policy aimed at improving general health

Multi-Attribute (Value) Analysis

1. Scoring each consequence against each of the lowest level attributes.
2. Bringing each set of attribute scores to the same scale by applying weights.
3. Adding up the weighted attribute scores to give an overall score for each consequence.

International Chernobyl Project

The Soviet request

"...an international experts' assessment of the concept which the USSR has evolved to enable the population to live safely in areas affected by radioactive contamination following the Chernobyl accident, and an evaluation of the effectiveness of the steps taken in these areas to safeguard the health of the population."

Objectives of Decision Conferences

- to enable some of the decision problems related to the Chernobyl accident to be structured efficiently and thus clarify and elucidate issues;
- to summarise for the International Chernobyl Project the key socio-economic and political factors that together with the physical, radiological and medical evidence influence the relocation and protective measures taken in the Republics;
- to illustrate the use and potential benefits of formal decision analysis methods and the techniques of decision conferencing for the resolution of complex issues.

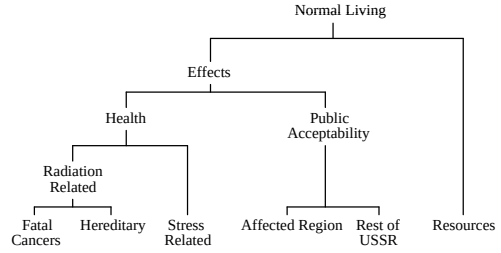
Key Issues

- Scale of accident
- Need of a concept of 'safe' living
- Health problems
- Stress
- Risk of water pollution
- Relocation not a panacea
- Lack of trust and understanding
- Safety of sarcophagus

USSR in 1986 to 1990

- Still feudal in Chrenobyl region
  - Extended family
  - Sundays and Mushrooms
- Perestroika
  - Command → demand economy
- Glasnost
  - Freedom of information
- More power devolved to republics
  - 3 involved: Ukraine, Byelorus, Russian Federation

Hierarchy used in 5th Conference



Decisions based on Intervention Levels

Measure of Dose

Above this level, relocation would be advised and offered

In between these levels, many countermeasures would be implemented to clean up the area and protect the population

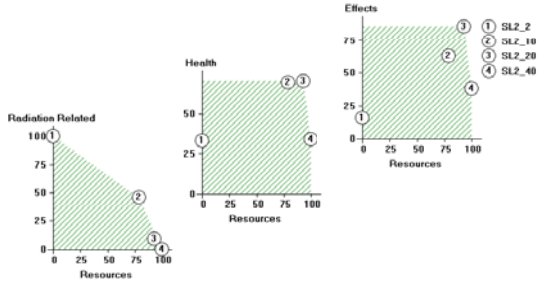
Observed

Below this level, there would be little need to do anything except reassure the population

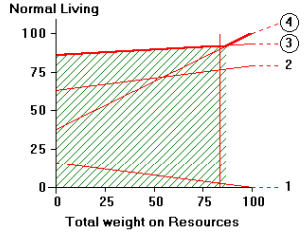
Details of the Countermeasure Strategies

Strategy	Number relocated (thousands)	Number protected by other means (thousands)	Estimated number of fatal cancers averted	Estimated number of hereditary effects averted	Cost (billions of roubles)
SL2_2	706	0	3200	500	28
SL2_10	160	546	1700	260	17
SL2_20	20	686	650	100	15
SL2_40	3	703	380	60	14

Pareto Plots



Sensitivity analysis



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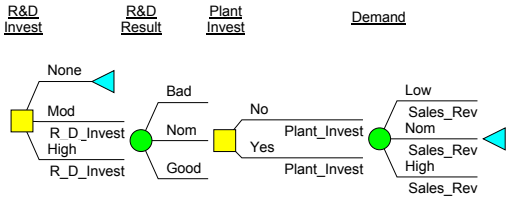
Types of uncertainties decision trees and influence diagrams

Uncertainty

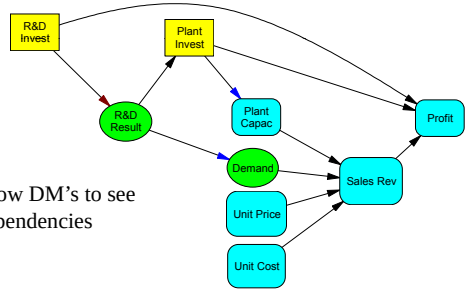
- Physical Randomness
  - Variation and randomness 'out there'
- Judgemental
  - The DMs beliefs and uncertainties
- Meaning / Ambiguity
  - aims & objectives
- Depth of Analysis
  - level of detail

Decision Tree Model



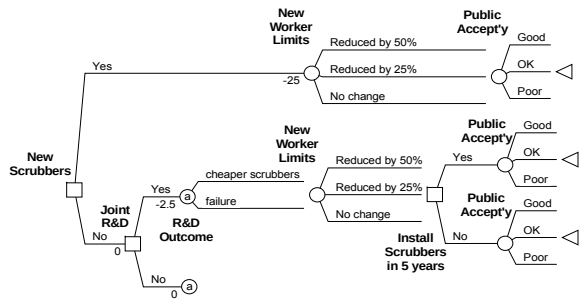
Building tree helps dm's think about key uncertainties and contingencies

Influence diagrams



ID's allow DM's to see dependencies

Scrubbers Case Study



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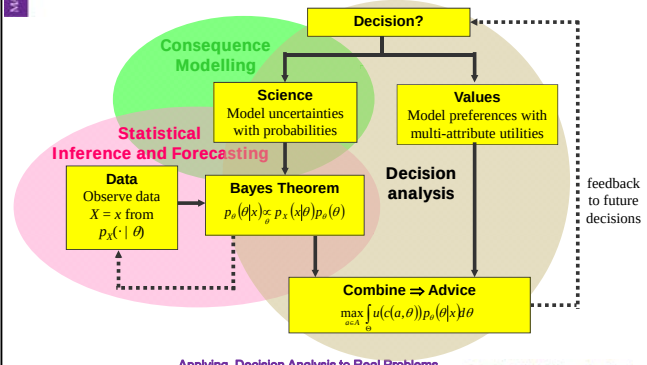
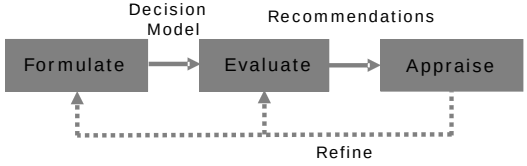
The decision analytic process

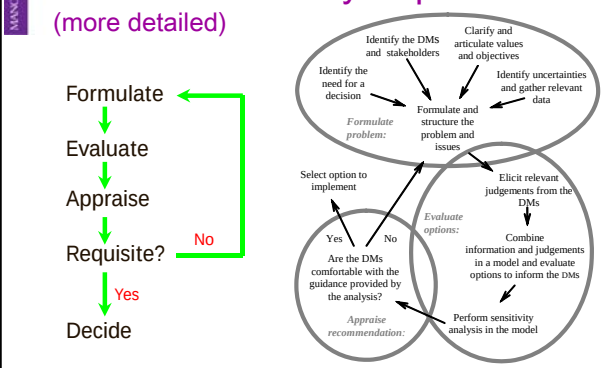
Bayesian analysis: modelling, inference, and decision



The decision analysis process



The decision analysis process
(more detailed)



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Group decision making

Most decisions take place in groups

- Groups can provide a very powerful setting in which decisions can be made
- But groups
  - can introduce biases
  - can behave dysfunctionally
  - Groupthink
- And, moreover, there are major conceptual issues about group decisions
  - Does group decision making exist?

Group Decision Making

Key Question:

Does group decision making exist???

Group intransitivity

Individual 1: $a \succ_1 b \succ_1 c$.
Individual 2: $b \succ_2 c \succ_2 a$.
Individual 3: $c \succ_3 a \succ_3 b$.

Simple Majority Vote

$a \succ_g b$, since 2 out of 3 prefer a to b.
$b \succ_g c$, since 2 out of 3 prefer b to c.
$c \succ_g a$, since 2 out of 3 prefer c to a.

Agenda Rigging

Individual 1: $a \succ_1 b \succ_1 c$.
Individual 2: $b \succ_2 c \succ_2 a$.
Individual 3: $c \succ_3 a \succ_3 b$.

but

$\left.\begin{matrix} a \\ b \end{matrix}\right\} \rightarrow \left.\begin{matrix} a \\ c \end{matrix}\right\} \rightarrow c$ $\qquad$ $\left.\begin{matrix} b \\ c \end{matrix}\right\} \rightarrow \left.\begin{matrix} b \\ a \end{matrix}\right\} \rightarrow a$

Arrow's Theorem

No constitution satisfies:

- Weak ordering
- Non Triviality
- Universal domain
- Independence of the irrelevant alternative
- Pareto Principle
- No Dictatorship

A group is a social process

- Need to facilitate the process:
  - foster effective communication between the members;
  - explore the issues in a creative, effective manner;
  - reduce unproductive tensions and disagreements;
  - protect the group from dysfunctional activities;
  - build a shared understanding;
  - build a commitment to implement the selected course of action.
- and support each member's own thought processes, judgements and decision making.
- Reflect on the group processes that go on in your group exercise.

In groups

- The leader should encourage each member to voice criticisms and doubts
- The leader should not voice his/her feelings until all others have spoken
- Use breakout groups to encourage independent patterns of thought and then challenge each.
- Bring in outsiders for fresh viewpoints
- Assign the role of devil's advocate explicitly
  - to **challenge** thinking

Individuals in groups should

- View differences of opinion as natural and helpful
- Avoid arguing blindly for their own assumptions and recommendations.
- Avoid making "win-lose" statements in their discussion.
- Avoid changing their mind simply to avoid conflict and reach agreement.
- But **challenge** constructively.

Overcoming overconfidence

[Groupthink ⇒ even greater overconfidence]

- seek feedback on past judgements
  - vital!!!
- consider similar past situations and what happened
- devil's advocates, court jesters
- recognise/reflect on judgement process

and

- **Challenge! Challenge!! Challenge!!!**

In summary

Analysis:

1. Create questions

2. Question questions **Challenge**

3. Answer questions

4. Question answers **Challenge**

Alistair Carruthers