Decision Analysis
Part 2:
Decision Trees

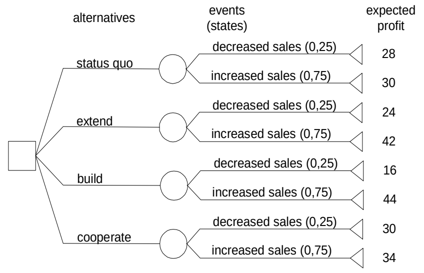
Working Example

Decision table (Payoff matrix)

		alternative			
		status quo	*extend*	*build*	*cooperate*
states	*decreased sales*	28	24	16	30
	increased sales	30	42	44	34

Working Example

Equivalent *decision tree*:



Decision Tree

Different from decision trees used in Machine Learning:

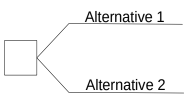
- different types of nodes
- always drawn horizontally, from left to right
- "hand-crafted", not learned from data

Decision tree represents the decision problem in terms of chains of consecutive *decisions* and chance *events*.

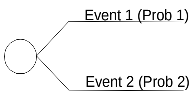
Time proceeds from *left to right*.

Uncertainties associated with chance events are modelled by *probabilities*.

Components of Decision Trees



Decision node:
represents alternatives



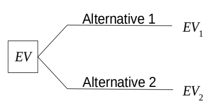
Chance Node:
represents events (states of nature)


Outcome (Value)

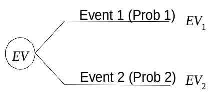
Terminal (End) Node:
represents consequences of decisions

Solving Decision Trees

From right to left:



$EV = \max_i EV_i$ [maximize profit]
or
$EV = \min_i EV_i$ [minimise losses]

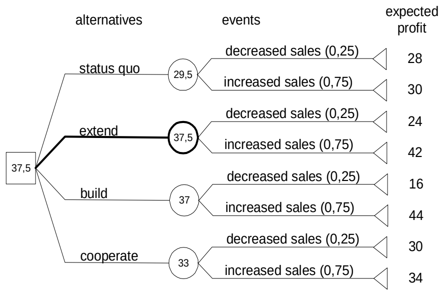


$EV = \sum_i p_i \, EV_i$

Outcome (Value)

$EV = \text{Value}$

Solved Decision Tree



Decision Tree Development

1. Place decision and chance nodes in a logical time order
2. Independent chance nodes can be placed in any order
3. Estimate probabilities of all chance events
4. The sum of probabilities in a chance node must be 1
5. In terminal nodes, specify consequences by a single performance measure, e.g.:
   - money,
   - aggregate utility or
   - results of a multiple criteria analysis

Common Mistakes

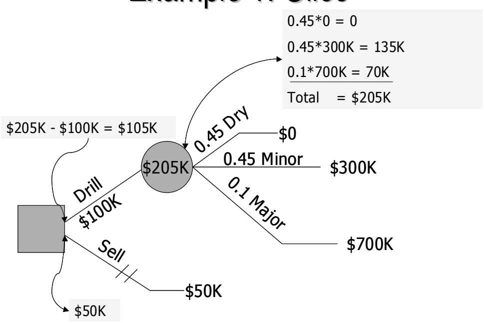
1. Decision and chance nodes are in wrong order:
   Only chance nodes whose results are known at the time of decision can precede a decision node
2. Incorrect derivation of chance probabilities:
   Chance probabilities depend on each other and decisions made
3. Chance events with probability 0 can be left out
4. When solving the tree:
   Maximising instead of minimising, or vice versa

Example 1: Oilco

Mobon Oil Company has a lease on an offshore oil site. The lease is about to expire and they are faced with either developing the field or selling the lease to Excel Oil Co. for $50,000. It costs approximately $100,000 to drill a well. There is a 45% chance that the well is dry, a 45% chance that the well will have a minor strike and a 10% chance that they will have a major strike. For a typical minor strike the revenues average $300,000. If the strike is major the revenues average $700,000. What should Mobon do?

Source: http://www.cs.jmu.edu/common/coursedocs/isat411/Decision%20analyis%20lectures2a.ppt

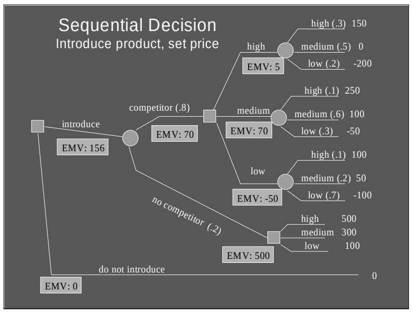
Example 1: Oilco



Recommendation: Drill!

Source: http://www.cs.jmu.edu/common/coursedocs/isat411/Decision%20analyis%20lectures2a.ppt

Example 2: Sequential Decision



Source: Decision Trees.
http://academic.udayton.edu/CharlesEbeling/MSC%20535/Lectures/Lesson%202/Decision_Trees/decision%20trees.ppt

Other Important Concepts

1. Value of Perfect Information
2. Risk Profile

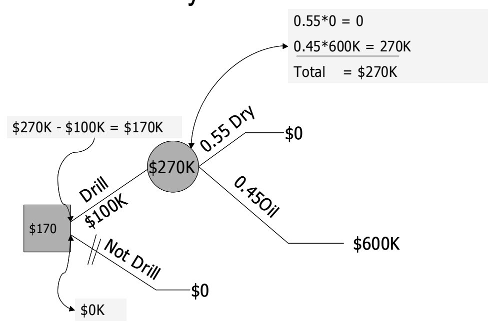
Value of Perfect Information

Example

- Oilco must determine whether of not to drill for oil in the South China Sea. It costs $100,000 to drill for oil and if oil is found the value of the oil is estimated to be $600,000. At present, Oilco believes there is a 45% chance that the field contains oil. What should Oilco do?
- What is the *value of perfect information* (knowledge of whether the field contains oil) to Oilco?

Source: http://www.cs.jmu.edu/common/coursedocs/isat411/Decision%20analyis%20lectures2a.ppt

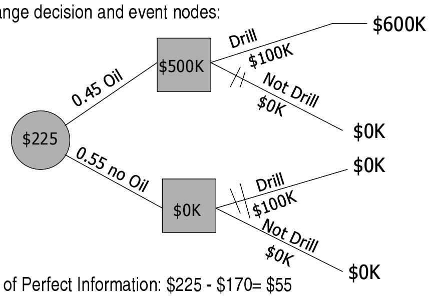
Ordinary Decision Tree



Recommendation: Drill!

Value of Perfect Information

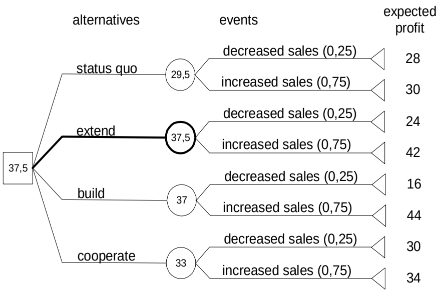
Exchange decision and event nodes:



Value of Perfect Information: $225 - $170= $55

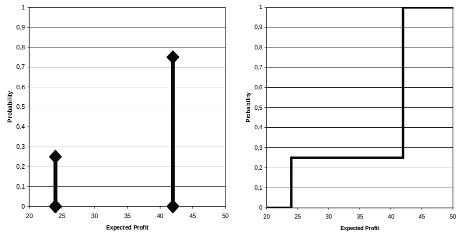
Risk Profile

Solved Decision Tree



Risk Profile

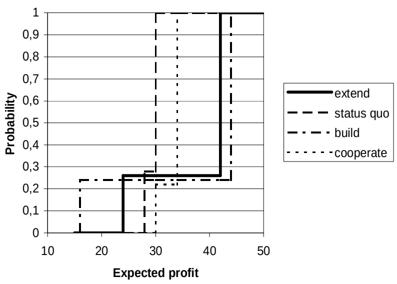
Alternative: *extend*



Probabilistic distribution   Cumulative distribution

Cumulative Risk Profile

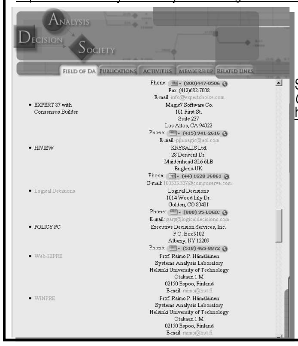
All alternatives



Decision Tree Software

Decision Analysis Software

http://decision-analysis.society.informs.org/Field/FieldSoftware.html



See also:
OR/MS Today, December 2006
http://www.lionhrtpub.com/orms/surveys/das/das.html

Decision Tree Software

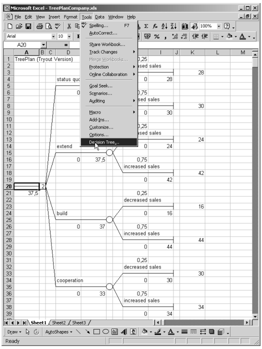
Add-Ins for Microsoft Excel:

- TreePlan: http://www.treeplan.com/
- PrecisionTree: http://www.palisade-europe.com/precisiontree/

Decision-Tree Development Programs:

- TreeAge Pro (DATA): http://www.treeage.com/
- DecisionPro: http://www.vanguardsw.com/
- DPL: http://www.syncopationsoftware.com/

TreePlan



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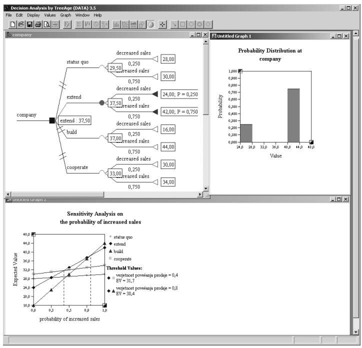
DATA



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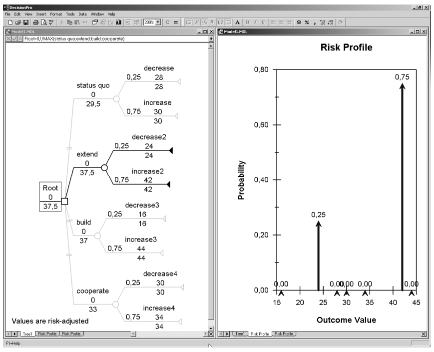
DecisionPro



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A Typical Application in Medicine

A Cost-Benefit Analysis of Testing for Influenza A in High-Risk Adults

William J. Hueston, MD
Joseph J. Benich III
Department of Family Medicine, Medical University of South Carolina, Charleston, SC

ABSTRACT

BACKGROUND Clinical diagnosis and empiric therapy have been strategies for treatment of suspected influenza in high-risk patients, but rapid tests for influenza have been introduced to help confirm cases. The aim of this study was to determine when rapid testing, empiric treatment, or no treatment is most cost-beneficial for high-risk adults with influenzalike respiratory tract illnesses.

METHODS We performed a cost-benefit analysis evaluating the comparative advantage of the strategies of empiric therapy, no treatment, or test and treat patients whose tests are positive. The analysis focused on a hypothetical population of patients who are at a high-risk for complications of influenza. Our main outcome was the cost of care for an episode of influenza taken from the human capital perspective.

RESULTS For older anti-influenza drugs (amantadine and rimantadine), rapid testing is not as cost-beneficial as empiric treatment, even when the prevalence of influenza is low. For the neuraminidase inhibitors, there is a narrow window of disease prevalence between 30% and 40% where testing is most cost-beneficial. When the disease likelihood is above this window, empiric treatment is preferred. Below this window, no treatment is more cost-beneficial. Even under the most favorable conditions, testing is preferred only for a small range of prevalence rates of influenza.

CONCLUSION When clinicians are planning to use the nonneuraminidase inhibitors to treat influenza, rapid testing is not the most cost-beneficial approach. Even when the more expensive neuraminidase inhibitors will be used, testing has a limited role in managing influenza in high-risk patients.

Ann Fam Med 2004;2:33-40. DOI: 10.1370/afm.34.

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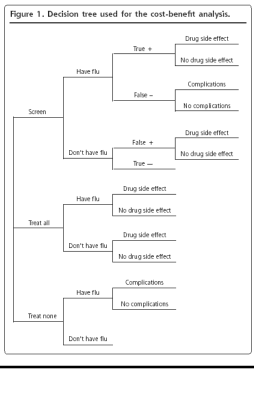
A Typical Application in Medicine

Figure 1. Decision tree used for the cost-benefit analysis.



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Questions

Compare decision tables with decision trees:
What do decision trees facilitate that decision tables don't?

Identify limitations and/or shortcomings of decision trees.

Identify types of decision problems suitable for the application of decision trees.

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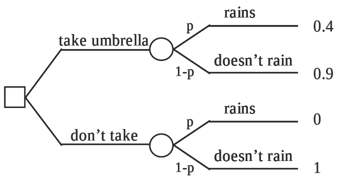
Exercise 1

Consider the decision tree:



1. Solve the tree for tomorrow's p
2. Do sensitivity analysis
3. Take the risk profile of your decision

Exercise 2

For the decision tree shown in the slide "Example 2: Sequential Decision" (Introduce Product):

1. do sensitivity anaysis with respect to p(*competitor*)
2. find the risk profile of alternative *introduce*.

Tree Development Exercise (1/3)

Service station problem:

- You are the owner of a service station on an intercity road. You have heard a rumour that the road may be upgraded or diverted along a different route. What do you do? What information will you need? How do you formulate a decision model?
- Think: before reading next slides, structure your own decision. You will need to specify an *objective*, identify *alternatives* available to you as the service station owner, and identify the *uncertainties* involved in this decision situation together with the possible *events*.

Adapted from: Making Decisions, http://www.imm.ecel.uwa.edu.au/unit450231/lectures/week%202.ppt

Tree Development Exercise (2/3)

Possible answers to the questions from the previous slide:
Objective: maximise the value of service station investment
Alternatives:

- *status quo*
- *sell*
- *extend*

Events:

- *unaltered* (p=0.5)
- *upgrade* (p=0.3)
- *divert* (p=0.2)

Tree Development Exercise (3/3)

Proceed as follows:

1. Define decision table (include *consequences*)
2. Convert decision table to decision tree
3. Calculate EV and identify the best alternative
4. Do sensitivity analysis with respect to p(*unaltered*) [which problem do you encounter here?]
5. Find the risk profile of the best alternative