
Based on:
- multi-attribute decision making
- expert systems
- machine learning
- fuzzy logic

Qualitative decision modelling:
- qualitative attributes
- decision rules

DEX and DEXi: Background

1. Multi-Attribute Decision Making
   - modeling using criteria and utility functions
   - problem decomposition and structuring
   - option evaluation and analysis

2. Expert Systems
   - qualitative (symbolic) variables
   - "If-Then" decision rules
   - decision model - knowledge base
   - emphasis on the explanation of results (DEX)

DEXi: Methodology and Software

A simple computer program for MADM that has five features:
- Creation and editing of:
  - mode structure (tree of attributes)
  - value scales of attributes
  - decision rules (i.e., using weights)
  - options and their desiderata (desktop)
- Eval with or without options (can handle missing values)
- Presentation of evaluation results within:
  - tables
  - charts
- "What-if" analyses
- Preparing a report

Stages of MADM (with DEXi)

1. Identification of Attributes
   - unstructured list of attributes
   - hierarchy (hierarchies) of attributes
   - measurement scales

2. Definition of Utility Functions (Decision Rules)

3. Evaluation and Analysis of Options
   - description of options (status quo analysis)
   - evaluation of options
   - evaluation

4. Implementation
Stages of MADM (with DEXi)

1. Problem Identification
   a. problem formulation
   b. formation of decision making group
   c. selection of decision making time horizon

2. Identification of Attributes
   a. unstructured list of attributes
   b. hierarchy (tree) of attributes
   c. measurement scales

3. Evaluation and Analysis of Options
   a. description of options (e.g., good, poor, aver., exc.)
   b. evaluation of options
   c. analysis

4. Implementation

1.a: Unstructured List of Attributes

Problem in Personnel Management
Select a Candidate for a Job (e.g., a project manager)

- education
- age
- experience
- references
- knowledge
- work approach
- ability to work in a group
- health
- ...  

Do not overlook important attributes!

1.b: Tree of Attributes

Create meaningful, related groups
Avoid aggregate attributes having more than three descendants

1.c: Scales

Scales are discrete, typically ordered from bad to good
Values should distinguish between importantly different characteristics
Their number should gradually increase from bottom to the root
2: Decision rules

Utility Functions, Bottom-Up Aggregation

<table>
<thead>
<tr>
<th>Co mm</th>
<th>Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>poor</td>
<td>more</td>
</tr>
<tr>
<td>poor</td>
<td>more</td>
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<td>poor</td>
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<td>good</td>
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<td>good</td>
<td>more</td>
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<td>good</td>
<td>more</td>
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3.a: Description of Options

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Formal</th>
<th>For Lang</th>
<th>Exper</th>
<th>Age</th>
<th>Comm</th>
<th>Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>PhD</td>
<td>act</td>
<td>more</td>
<td>25-34</td>
<td>more</td>
<td>B</td>
</tr>
</tbody>
</table>

3.b: Evaluation and Analysis of Options

1. Evaluation
   - proceeds from bottom (basic attributes) to the root
   - results: qualitative evaluation of each option
   - handle missing (IDEX) or imprecise (IDEX) opt values

2. Analysis
   - iterative inspection of results
   - white-box analysis
   - analysis:
     - compare options
     - "1" and "yes"
     - select "ve explanation
     - reports
     - charts

3. Evaluation of an Option

Candidate A
3.b: Evaluation of Options

3.c: What-If Analysis

Candidate A

Employ

good

Years

acc
good

Abit

Test

good

Comm

leader

more

Formal

For Lang

Exp

good

Age

21-25

good

MSc

PhD

good

no effect

3.c: “±1” Analysis

3.c: Compare options
3.c: Selective Explanation

Candidate B

Charts and Reports

DEX and DEXi: Experience

- Wide applicability to various application areas
- Usually, solutions are specific (non-general)

1. Model development time
   - Highly problem-dependent from hours to months
   - Typically 2 to 10 days

2. The most difficult stage
   - Designing the tree of attributes

3. Appropriate decision problems
   - Many attributes (> 10)
   - Many options (> 10)
   - Non-deterministic or missing data
   - Requires decision making (communication and explanation)
   - As a rule in expert systems family (expert system, PRM)

DEX in DEXi: Future

- Combined qualitative and quantitative models
- Extensions
  - Data Mining (e.g., machine learning of models by HINT)
  - Data Bases, Data Warehouses, OLAP
- Software
  - "Dex Machine": Low level OO library for QM models
  - Various types and levels of GUI

DEX and DEXi: Summary

1. Combination of
   - Multi-attribute decision making and expert systems
2. Characteristics:
   - Qualitative (symbolic) decision making
   - Explanation and analysis
   - Active support in the acquisition of decision rules
3. Applicability:
   - For complex real-world problems
   - Over 50 real-life applications
**Exercise**

1. Take one of the already defined "empty" models shown on the next slide.
2. Define a utility function (decision rules) in that model.
3. Define and describe a few (about 4) options.
4. Evaluate and analyse the options.
5. Extend the model:
   - add and/or refine a few attributes (including the scales and ranks).
   - repeat the steps 2, and 4.
6. Prepare and print out (or save) a report.

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**Models**

**Portable Computer**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programming</td>
<td>Performance</td>
</tr>
<tr>
<td>KNOWLEDGE</td>
<td>Knowledge of the Programmer</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>Working Experience</td>
</tr>
<tr>
<td>SPECIAL</td>
<td>Specialized Knowledge</td>
</tr>
<tr>
<td>WORK</td>
<td>Quality of Programmer's Work</td>
</tr>
<tr>
<td>QUALITY</td>
<td>Quality of the Results</td>
</tr>
<tr>
<td>EFFECTIVE</td>
<td>Work Effectiveness: Are the results delivered in time?</td>
</tr>
<tr>
<td>APPROACH</td>
<td>Working Approach</td>
</tr>
<tr>
<td>TEAM</td>
<td>Attitude to Team Work</td>
</tr>
<tr>
<td>PERSONAL</td>
<td>Personal Characteristics</td>
</tr>
<tr>
<td>INITIATIVE</td>
<td>Self-Initiativeness</td>
</tr>
<tr>
<td>CREATIVE</td>
<td>Creativity</td>
</tr>
</tbody>
</table>

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**Car Selection**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>PORTABLE</td>
<td>Portable computer</td>
</tr>
<tr>
<td>COMMERCIAL</td>
<td>Price [in Euro]</td>
</tr>
<tr>
<td>TECNICAL</td>
<td>Technical specifications</td>
</tr>
<tr>
<td>INTERNAL</td>
<td>Processor</td>
</tr>
<tr>
<td>DISK</td>
<td>Memory</td>
</tr>
<tr>
<td>EXTERNAL</td>
<td>Drive</td>
</tr>
<tr>
<td>MONITOR</td>
<td>Monitor</td>
</tr>
<tr>
<td>KEYBOARD</td>
<td>Keyboard</td>
</tr>
<tr>
<td>AUTONOMY</td>
<td>Autonomy</td>
</tr>
</tbody>
</table>

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**Evaluation of Companies**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENTERPRISE</td>
<td>Performance evaluation of enterprises</td>
</tr>
<tr>
<td>FINANCIAL</td>
<td>Profitability</td>
</tr>
<tr>
<td>RETURN</td>
<td>Profitability</td>
</tr>
<tr>
<td>PROFIT</td>
<td>Profitability</td>
</tr>
<tr>
<td>LIQUID</td>
<td>Profitability</td>
</tr>
<tr>
<td>ECONOMIC</td>
<td>Product Economic</td>
</tr>
<tr>
<td>PRODUCT</td>
<td>Capacity</td>
</tr>
</tbody>
</table>

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**Car Quality**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAR</td>
<td>Quality of a car</td>
</tr>
<tr>
<td>PRICE</td>
<td>Price of a car</td>
</tr>
<tr>
<td>BUY.PRICE</td>
<td>Buying price</td>
</tr>
<tr>
<td>MAINT.PRICE</td>
<td>Maintenance price</td>
</tr>
<tr>
<td>TEC.CHAR.</td>
<td>Technical characteristics</td>
</tr>
<tr>
<td>COMFORT</td>
<td>Comfort</td>
</tr>
<tr>
<td>#PERS</td>
<td>Maximum number of passengers</td>
</tr>
<tr>
<td>#DOORS</td>
<td>Number of doors</td>
</tr>
<tr>
<td>LUGGAGE</td>
<td>Size of luggage boot</td>
</tr>
<tr>
<td>SAFETY</td>
<td>Car's safety</td>
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</tbody>
</table>