

Multiple Criteria Decision Analysis

— *Problems, Models, Methods and Applications*

Professor Jian-Bo Yang

Director of Decision and Cognitive Sciences Research Centre

Manchester Business School

The University of Manchester

Room: F36 / MBS East

Tel: 0161 200 3427 (Ext: 63427)

Email: jian-bo.yang@mbs.ac.uk

Web: www.personal.mbs.ac.uk/jbyang

Main Topics of the Session

- **Multiple criteria decision analysis – an introduction**
- Multiple objective optimization problems in real world
- Multiple criteria assessment and decision analysis problems in real world
- Decision matrix and MCDA explained in graph
- Additive value function approach in MCDA
- Deal with uncertainties in MCDA
- Evidential reasoning MCDA – concept, model, process and tool
- A snapshot of real world MCDA applications

Decision Making at Different Levels

(Anthony's Model, 1965)

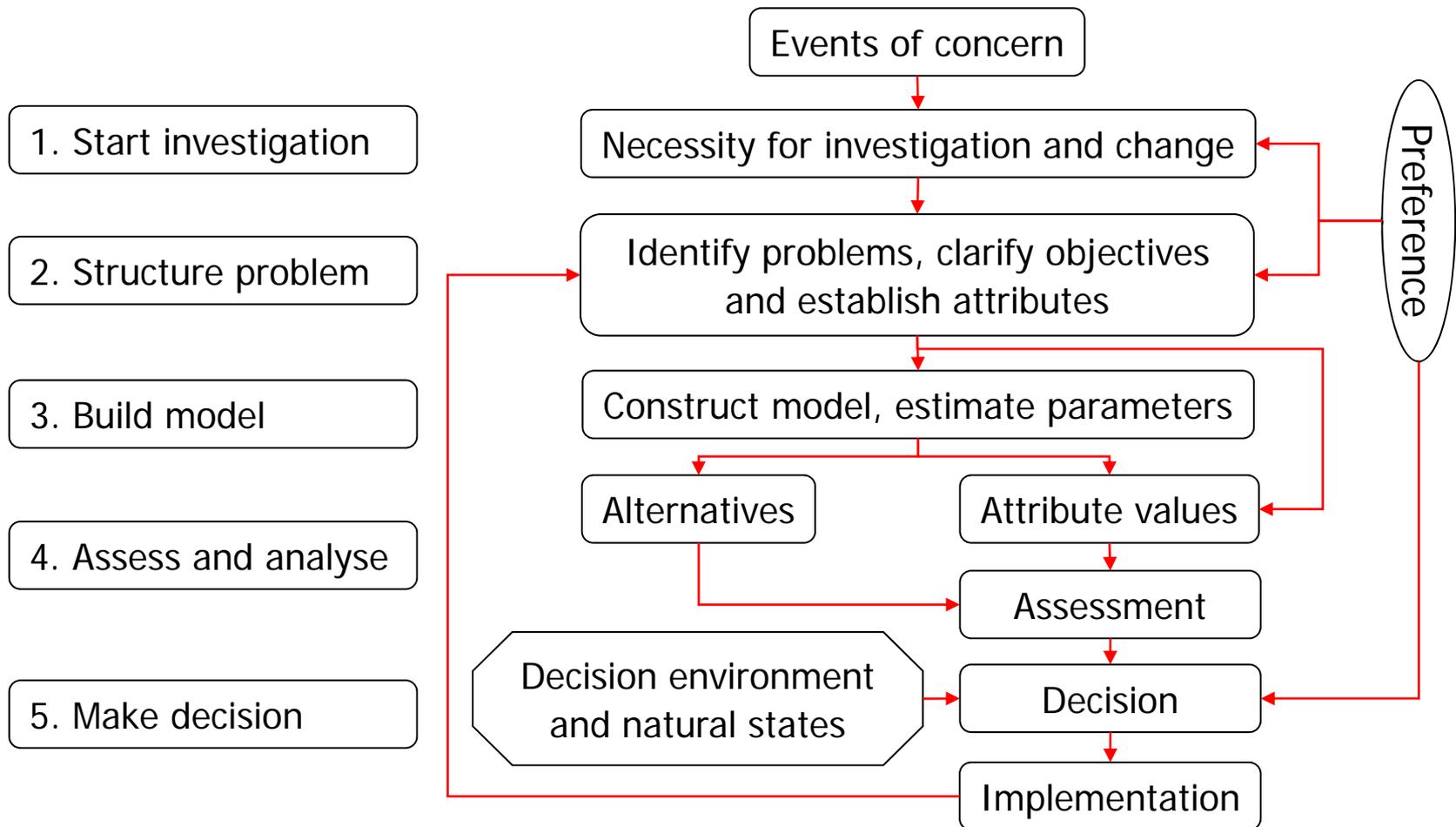


Multiple Criteria Decision Analysis

Decision Issues at Different Levels

- **Strategic planning**
 - New business opportunities
 - Competition strategies
 - Technology adoption
 - Strategic partnership
- **Managerial control**
 - Financial control
 - Project control
 - Quality control
 - Risk control
 - HR control
- **Operational control**
 - Task scheduling
 - Production optimization
 - Coordination
 - Skill development

Multiple Criteria Decision Making – Typical solution procedure



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Multi-objective optimization in real world

– *Production planning and scheduling*

- Multiple objective optimisation for production planning in oil refinery
- Large scale optimisation methods and software
- Multiple criteria decision analysis
- Automatic model update
- Decision support systems



<http://www.astreetjournalist.com/2010/01/11/country%E2%80%99s-biggest-project-under-the-shadow-of-heavy-strike/>

Multi-objective optimization in real world

– *Made-to-order engineering product design*

- **Offshore structures**
 - **Construction cost**
 - **Layout optimisation**



<http://www.offshore-technology.com/contractors/pipes/project-materials/project-materials1.html>

Multi-objective optimization in real world

– *Made-to-order engineering product design*

- **Offshore structures**
 - **Construction cost**
 - **Layout optimisation**
- **Optimal ship design**
 - **Transportation cost**
 - **Light ship mass**
 - **Annual cargo**



<http://www.istockphoto.com/stock-photo-6151204-cargo-container-ship-entering-the-harbor.php>

Multi-objective optimization in real world

– *Made-to-order engineering product design*

- **Offshore structures**
 - Construction cost
 - Layout optimisation
- **Optimal ship design**
 - Transportation cost
 - Light ship mass
 - Annual cargo
- **Optimal ferry design**
 - Safety measures



<http://blogs.seattleweekly.com/dailyweekly/2007/09/>

Multi-objective optimization in real world

– Project portfolio analysis and management

 **Automotive**

 **Mercedes S Class**
MCU's
Night Vision

 **BMW X5**
MCU's
Dynamic Drive

 **Honda Stepwagon**
MCU & Sensor
-Airbag

 **Ford Fusion**
i.MX31 (MPU)
Sync

 **Aston Martin DB9**
Sensors
Airbag

 **Ducati 696**
S12 & Pressure Sensor
ECU

 **Networking**

 **Routers & Switches**
MPU

 **Factory & Aerospace**
MPU, DSP

 **Surveillance & Conferencing**
MPU, DSP

 **Printers**
MPU

 **Speaker**

 **Industrial**

 **Insulin Pump**
MCU's

 **Blood Pressure**
Meter
Pressure Sensors

 **Washer**
MCU's
Sensors

 **Toaster**
MCU's

 **Power Meter**
MCU's
802.15.4 (Zigbee)

 **Consumer**

 **HP Photosmart eStation**
and 7" detachable wireless
Android tablet with i.MX51

 **OZing**
tablet
with
i.MX51

 **Kindle** with i.MX35, Sensors &
PMIC

 **Philips Gogear Connect**
Tablet, i.MX51

Multi-objective optimization in real world

– *Project portfolio analysis and management*

Simulator

Portfolio

Name: APP Jun07

Development Start Date: []

Development Horizon (Yrs): []

Simulation Start Date: []

Simulation Horizon (Yrs): []

Objective Function

Maximize Portfolio NPV

Maximize Operating Income

Maximize Gross Profit

Maximize Portfolio Revenue

Maximize Core HR Util (FTE)

Portfolio Metrics

NPV (M\$): []

Gross Profit (M\$): []

Revenue (M\$): []

Development Cost (M\$): []

HR Cost (M\$): []

Operating Income (M\$): []

Gross Margin (%): []

Headcount Utilization (%): []

Development Budget (%): []

Core HR Utilization (%): []

All Projects Portfolio (APP)

Force In	Project	NPV (M\$)	Op. Income (M\$)	Gr. Profit (M\$)	Gr. Margin %	Revenue (M\$)	HR Cost (M\$)
----------	---------	-----------	------------------	------------------	--------------	---------------	---------------

Loading 194 Projects - [unclear]

19%

Cancel

Solution

Project NPV

Eff. Frontier

Refresh

Constraints

Settings

Optimize

Close

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Multi-Criteria Decision Analysis in real world

– *Design selection of engineering products*

- Offshore structures
- Container ship
- Cargo ship
- Roll-on roll-off ferry
- Aircraft
- Car
- Computer
- Motorcycle
- house
- ...



<http://www.lodic.no/?side=1016>



<http://rmsponline.com/>



<http://www.freefoto.com/preview/806-30-8702?ffid=806-30-8702>



<http://www.freefoto.com/preview/2026-05-1?ffid=2026-05-1>



<http://www.dicts.info/picture-dictionary.php?w=aircraft>



<http://www.sustainabilitymatters.net.au/news/43589-ABB-and-GM-to-collaborate-on-electric-car-battery-research>

Multi-Criteria Decision Analysis in real world

– *Risk & safety analysis of products and systems*

- Offshore structures
- Cargo ship
- Container ship
- Roll-on roll-off ferry
- Nuclear plant
- Food and drink
- Sea port
- Air port
- Hospital
- ...



<http://science.howstuffworks.com/environmental/energy/offshore-drilling.htm>



<http://www.guardian.co.uk/uk/2008/jan/15/1>



<http://xmb.stuffcanuse.com/xmb/viewthread.php?tid=4175>



http://www.nypost.com/p/news/international/item_U8RbcKY6OO7zrVYIKFhABM



<http://www.alternavox.net/the-fukushima-nuclear-plant-accident-reaches-category-4>



www.shutterstock.com · 15461539

Multi-Criteria Decision Analysis in real world

– *Prioritise voices of customer via surveys (GM)*

<http://www.carbuyersnotebook.com/2011-chevy-cruze-pictured/>

<http://news.discovery.com/tech/gm-urban-car-china.html>

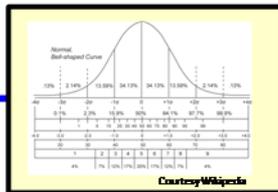


Voice of customer

Survey conducted by the firm

Survey bought from external agency

Product clinic



Multi-Criteria Decision Analysis in real world

– *Prioritise voices of customer using surveys*

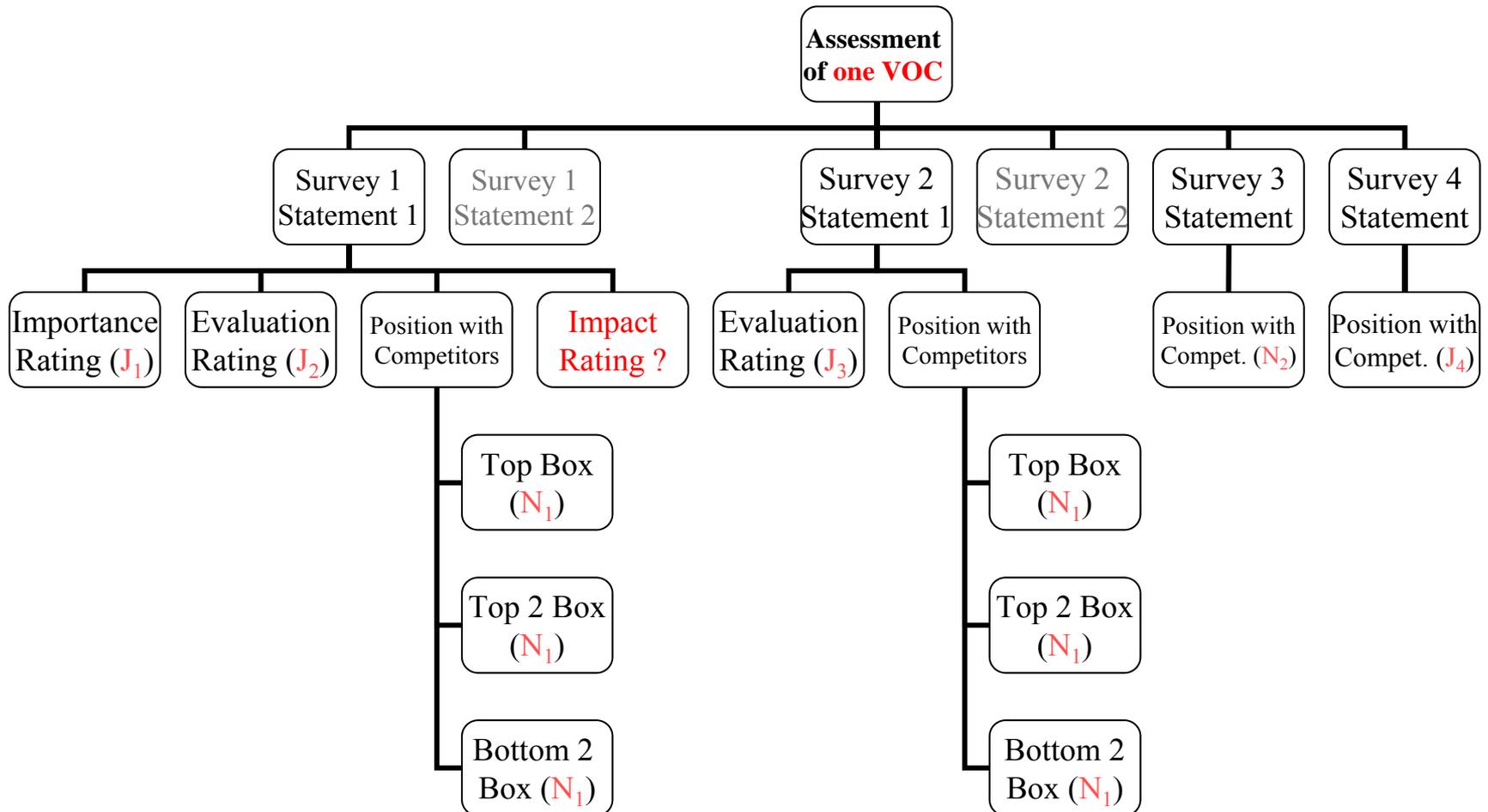
SCALE INCOMPATIBILITY IN SURVEYS

Survey 1	Survey 2	Survey 3
1: Disagree Strongly	1: Not Good	1: Unacceptable
2: Disagree	2: Good	3: Below Average
3: Neutral	3: Very Good	5: Average
4: Agree	4: Excellent	7: Good
5: Agree Strongly	5: Truly Outstanding	10: Outstanding

- **Surveys use different rating scales: Limited control if not in-house**
- **Handling incompatibility of rating scales**
 - Define common scale and create transformation functions
 - Define criteria that are independent of scales

Multi-Criteria Decision Analysis in real world

– *Prioritise voices of customer using surveys*



Multi-Criteria Decision Analysis in real world

– Business excellence self-assessment: EFQM



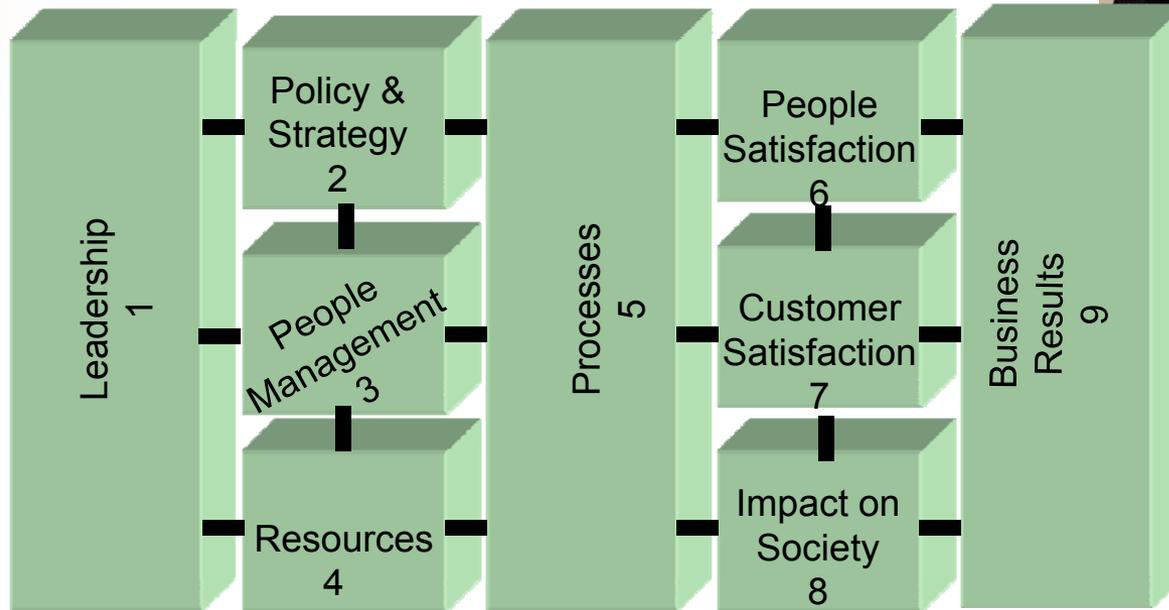
TOURISM ■ HOSPITALITY ■ LEISURE

<http://www.bestpracticeforum.org/business-excellence-awards.aspx>

Innovation and Learning



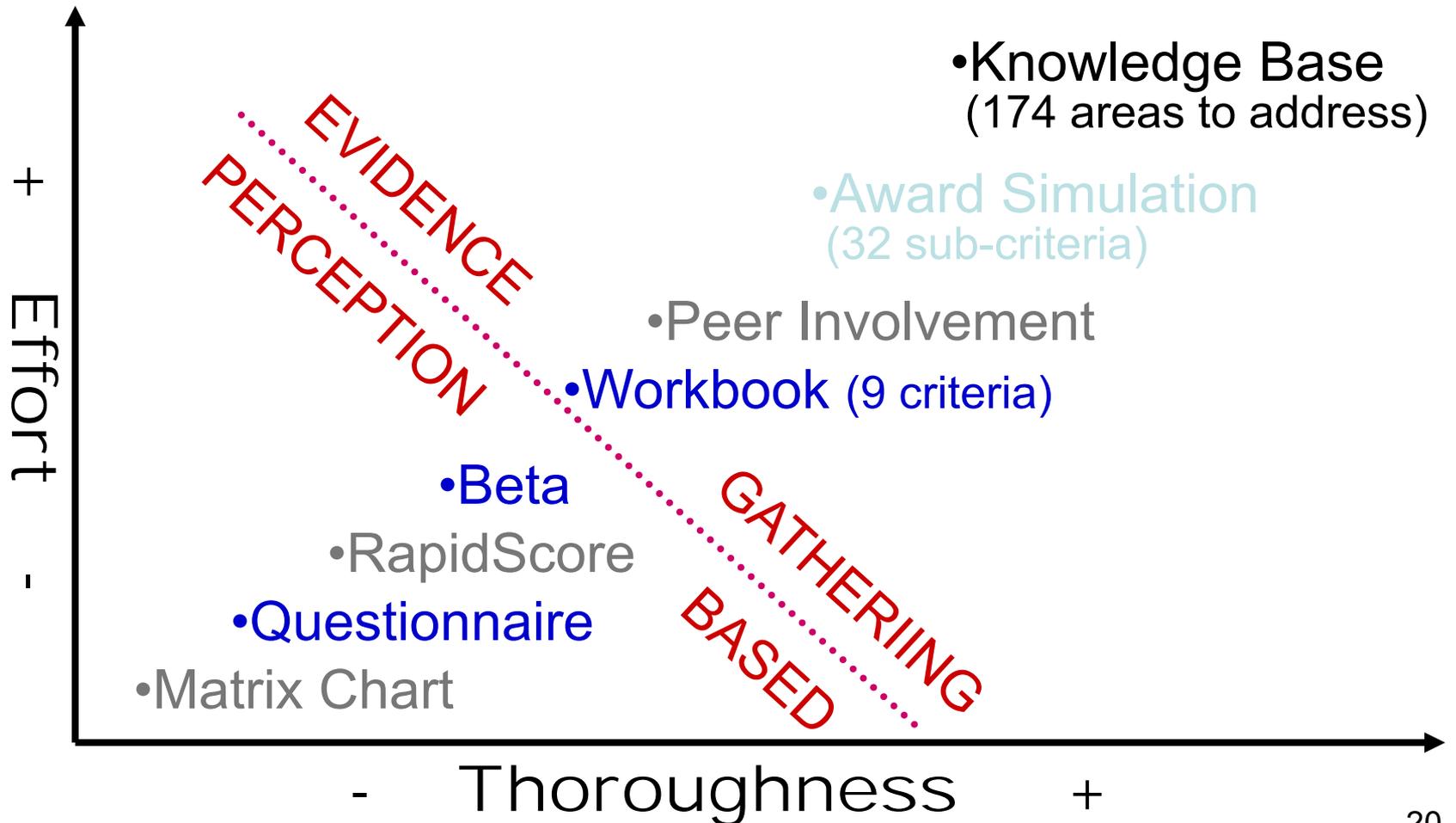
http://newsweaver.ie/failte_ireland/e_article000969204.cfm?x=bbl71MH_b3T1MJrq.w



Enablers → Results

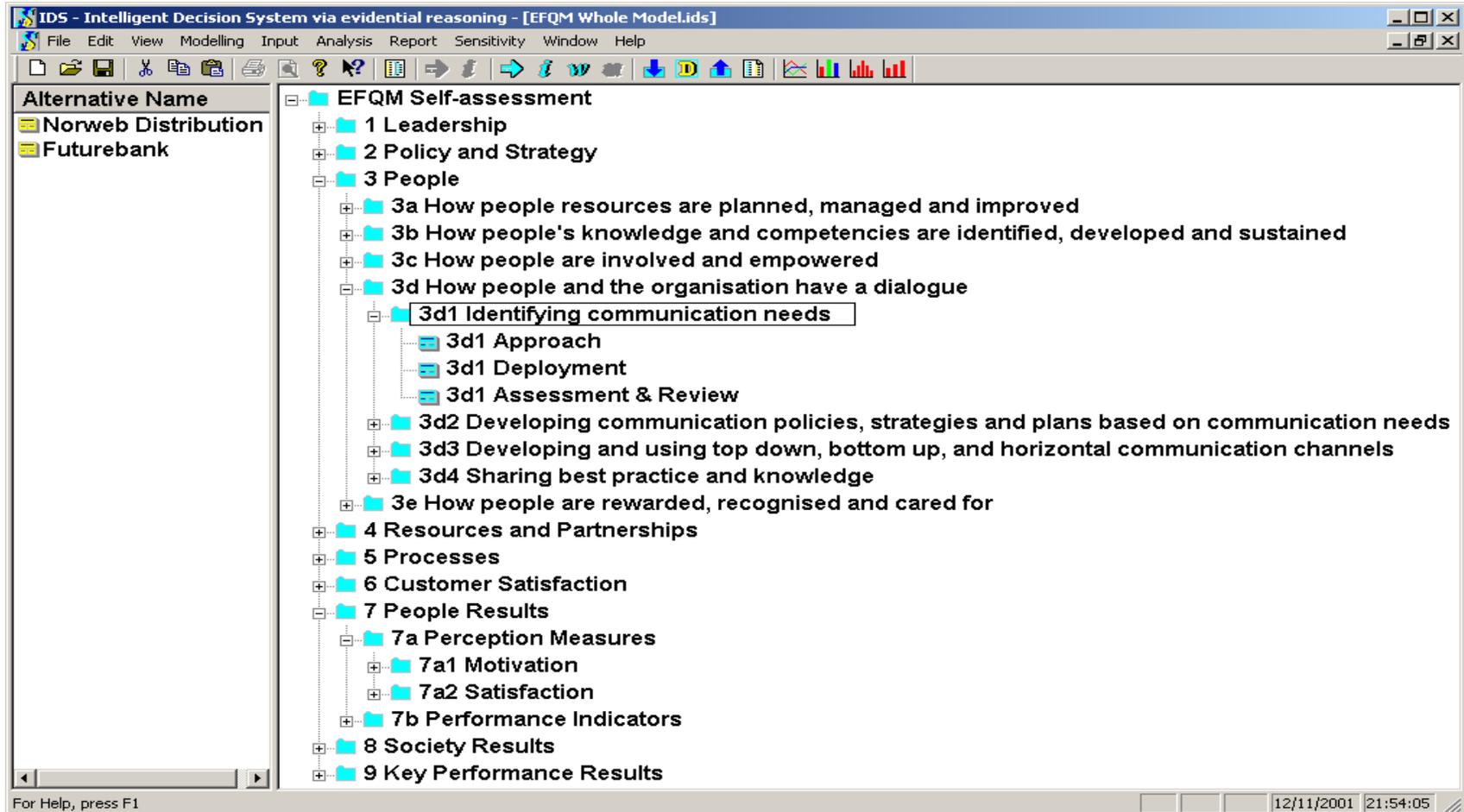
Multi-Criteria Decision Analysis in real world

– Business excellence self-assessment: EFQM



EFQM Self-Assessment Model:

For total quality management in an organisation



Intelligent *D*ecision *S*ystem (*IDS*): Evidence Mapping Window

IDS Dialog: Utility Company 1999 on Approach (5a.1)

Grade definitions:

Award Winners

- Key business processes and support processes are defined and documented to deliver policy and strategy. Flowcharts are used.
- A well defined and developed process exists to identify key business processes and support processes.
- relationships identified between individual products/services and processes.

Evidence provided:

1. Key processes and support processes have been identified and mapped.
The Management System manual describes links between the documentation produced and the delivery of the business goal through key performance measures.
2. Some departments have developed and documented their own processes and this need to be integrated within the one system.

Provide comments as follows:

1. Clear evidence shows that the key processes have been identified to deliver policy and strategy which matches grade B.

2. However, the system is not fully integrated and the approach still need time to be mature. Therefore C would be graded to this consideration.

To my degree of belief, B(0.6) C(0.4) would be a balanced score.

Buttons: OK, Cancel, Help, Copy, Paste, Cut, Undo

Multi-Criteria Decision Analysis in real world – *Supplier assessment and selection*

Supplier Assessment

Quality

Supply Chain Evaluation

Technical Competence evaluation

Total Cost Evaluation

General Factors Evaluation

After Sales Evaluation

Enviroethical

Leadership and Strategy

Project Management

Customer Needs

E - Readiness



<http://www.electricalequipment.co/siemens-process-instrumentation/>



<http://www.franke-gmbh.com/en/news/detail.php?id=12>

Supplier Assessment Model (Siemens UK)

Question & quantitative answers

6. After Sales Evaluation

6.1 Product Support

6.1.6 What is your response time?

Answers:

- 1> 1 – 2 hours
- 2> 3 – 4 hours
- 3> 5 – 6 hours
- 4> 7 – 8 hours

Supplier Assessment Model (Siemens UK)

Question & multiple choice answers

1. Quality

1.5 Quality Performance of Supplier

1.5.4 Are quality costs measured, monitored and published?

Answers:

- 1> No
- 2> Yes, occasionally
- 3> Yes, with improvement plans prioritised
- 4> Yes, with management review done regularly

Supplier Assessment Model (Siemens UK)

Question & Yes / No answers

2. Supply Chain Evaluation

2.1 Performance Measures

2.1.27 Which of the following criteria are used to measure the performance?

Answers: (Yes / No)

2.1.27.1 Purchase savings

2.1.27.2 Availability of stocks

2.1.27.3 Number of purchase orders outstanding

2.1.27.4 Level of inventory

2.1.27.5 Stock turnover

2.1.27.6 Standard cost variance

Supplier Assessment Model (Siemens UK)

Overall assessment grade (TQM Concept)

Supplier Classification

World Class	(ideal)
Award winners	(reliable)
Improvers	(potential)
Drifters	(unfavourable)
Uncommitted	(unqualified)

Supplier Assessment Model (Siemens UK)

Propagation of quantitative assessment

Response time \Leftrightarrow After Sales Evaluation

1 hour or less \Leftrightarrow (World Class)

3 hours \Leftrightarrow (Award winners)

5 hours \Leftrightarrow (Improvers)

7 hours \Leftrightarrow (Drifters)

8 or above \Leftrightarrow (Uncommitted)

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Multi-Criteria Decision Analysis

Traditional problem modelling method

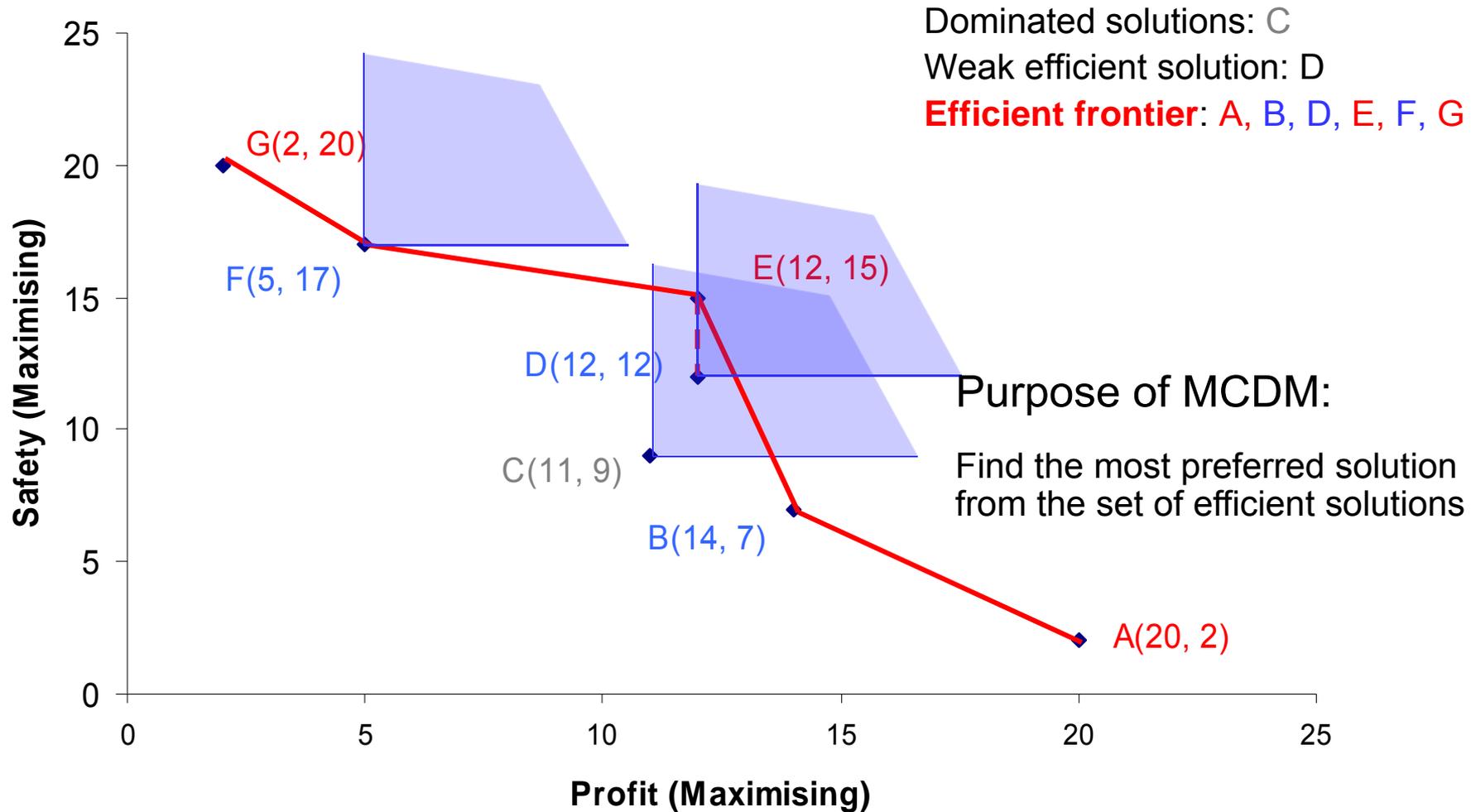
- Traditional Decision Matrix – Average Point Assessment

	Attribute 1	Attribute 2	Attribute n
Alternative 1	A_{11}	A_{12}		A_{1n}
Alternative 2	A_{21}	A_{22}		A_{2n}
.....				
Alternative m	A_{m1}	A_{m2}		A_{mn}

It uses average numbers to assess each alternative on all criteria

MCDM – Graphic Interpretation for

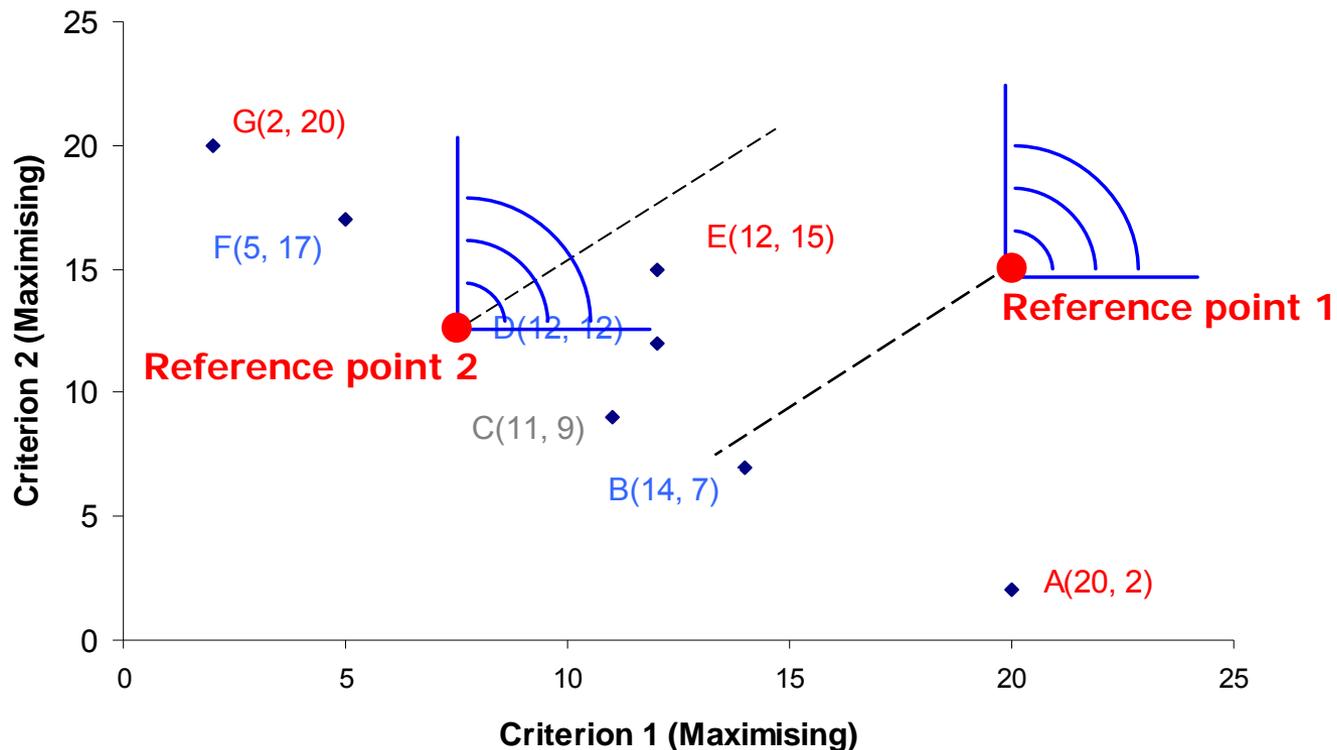
Dominated solutions, efficient solution, efficient frontier



Distance-based Preference Modelling

Aspiration level models (minimax distance)

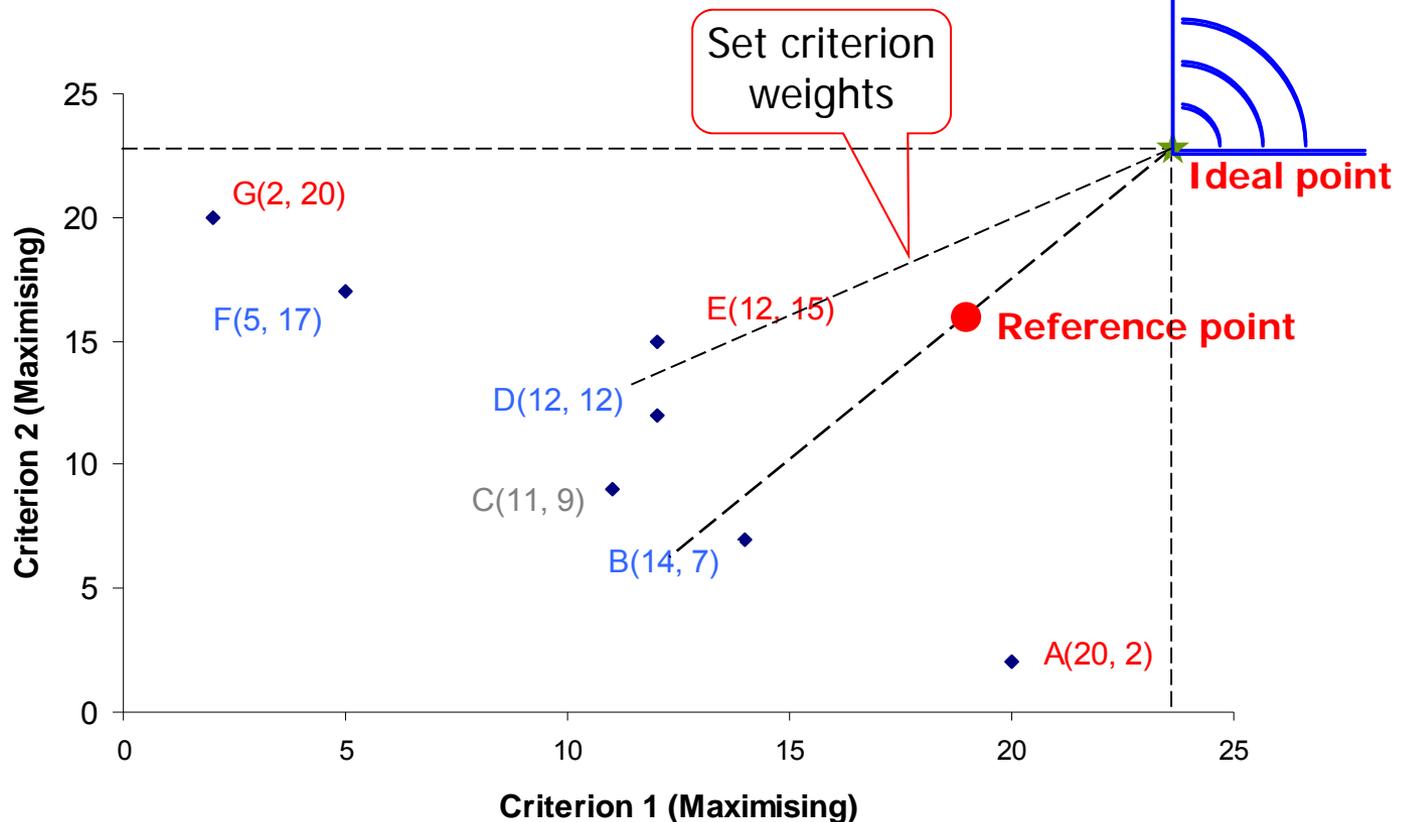
Reference point models: Set a reference point and find an alternative closest to the reference point in certain distance measure.



Distance-based Preference Modelling

Ideal point models (minimax distance)

Ideal point models: Set an ideal reference point and find an alternative closest to the ideal point in certain distance measure.



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Additive Value Function Approach

Assessment of postgraduate schools – example 1

Original Decision Matrix

	<i>Average book (y_1, number)</i>	<i>Student / staff (y_2, ratio)</i>	<i>Research grant (y_3, \$,000)</i>	<i>Graduation delayed (y_4, %)</i>
<i>School 1</i>	0.1	5	5,000	4.7
<i>School 2</i>	0.2	7	4,000	2.2
<i>School 3</i>	0.6	10	1,260	3.0
<i>School 4</i>	0.3	4	3,000	3.9
<i>School 5</i>	2.8	2	284	1.2

Assign Importance Weights by Comparisons

School performance assessment example

Comparisons: Suppose the most important criterion of the four criteria for school performance assessment is “research grant”.

1. Compare its importance with each of the other criteria:
“Research grant” is **twice** as important as “books”, $\omega_3/\omega_1 = 2$
“Research grant” is **1.5 times** as important as “ratio”, $\omega_3/\omega_2 = 1.5$
“Research grant” is **3 times** as important as “graduation”, $\omega_3/\omega_4 = 3$

Solve the four linear equations:

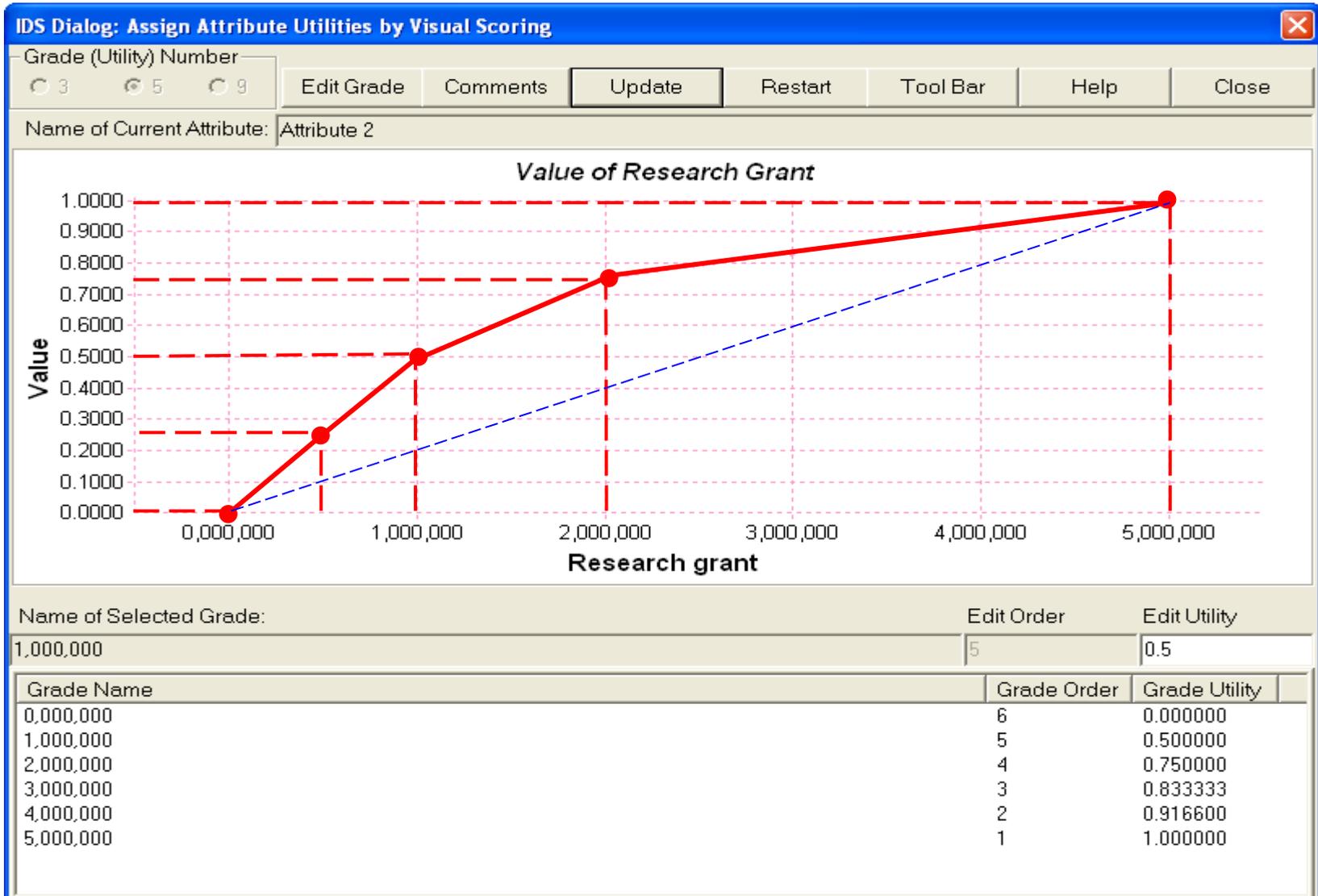
$$\omega_3 - 2\omega_1 = 0, \omega_3 - 1.5\omega_2 = 0, \omega_3 - 3\omega_4 = 0, \omega_1 + \omega_2 + \omega_3 + \omega_4 = 1$$

So, the weights of the four criteria are given by

$$\omega_1 = 0.2, \omega_2 = 0.2667, \omega_3 = 0.4, \omega_4 = 0.1333$$

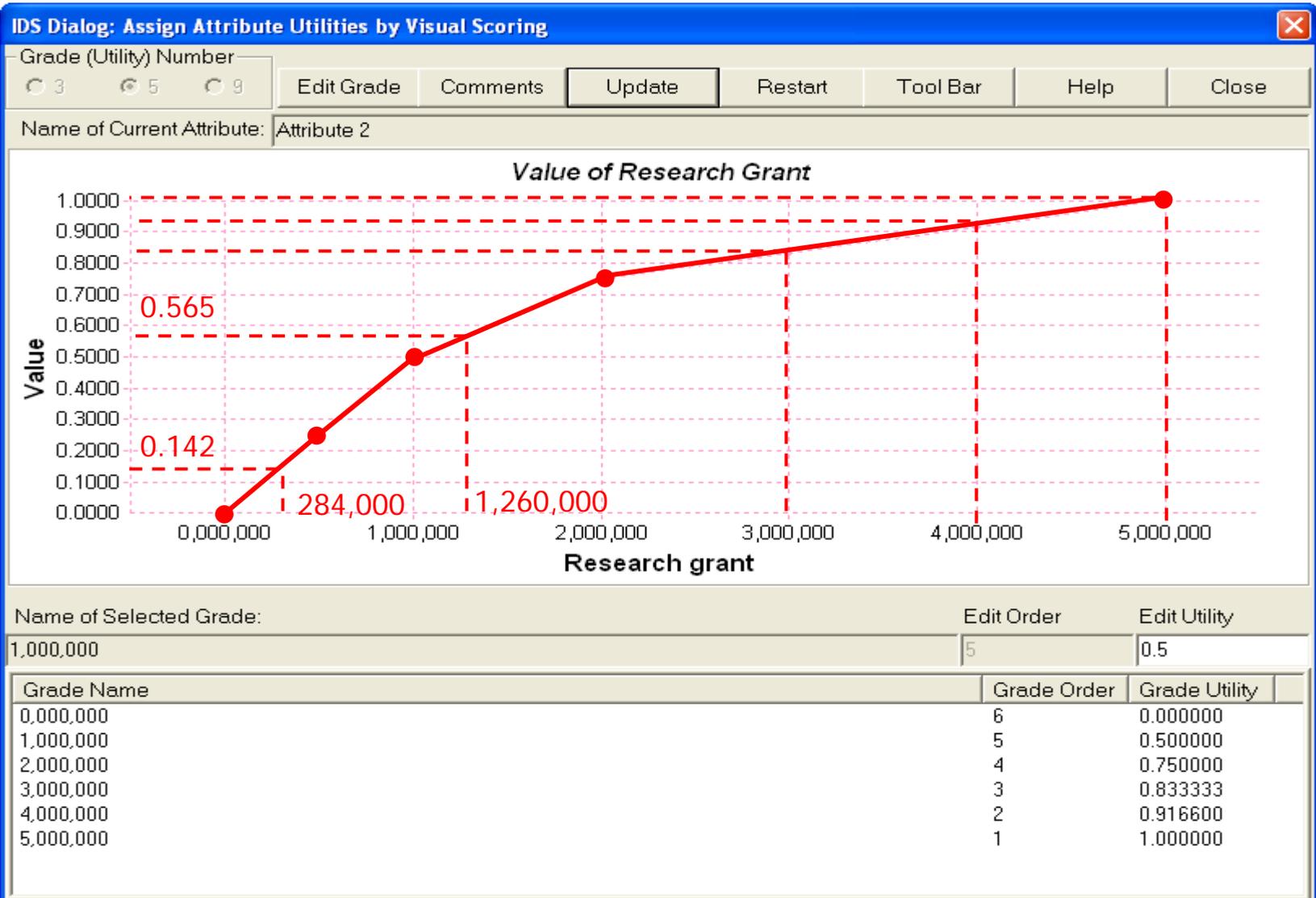
Definition of A Partial Value Function

Direct assessment via visual aid – v_3



Look up Partial Value Function

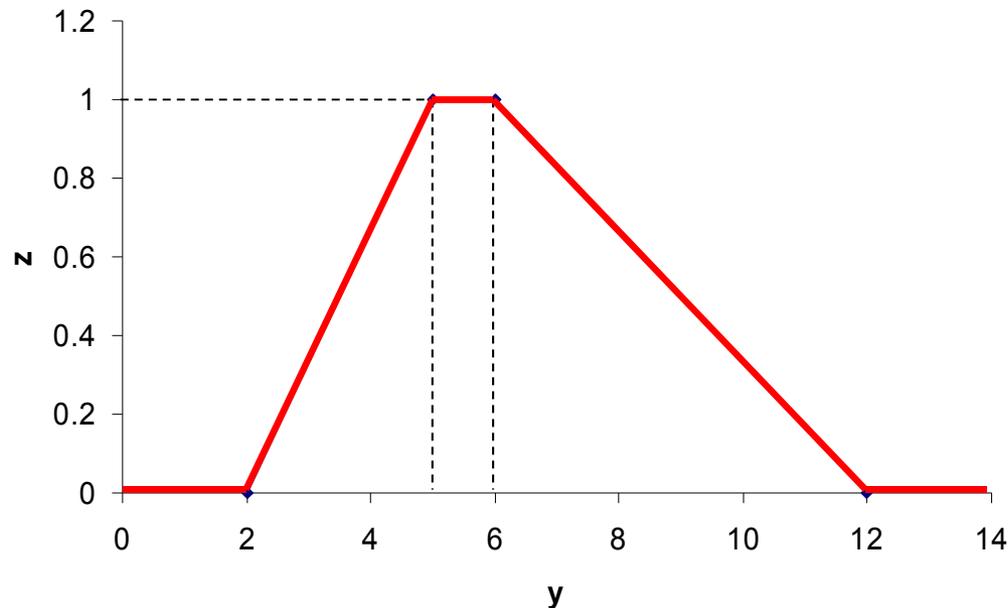
To get values for research grant – v_3



Pre-processing Data Collected

Transformation of data with optimal interval

Concept: For some criteria neither larger nor smaller is desirable, such as **student and staff ratio**. A high ratio may lead to the compromise of quality, but a low ratio means low workload for staff. A desirable ratio may be shown in the following diagram



Additive Value Function Approach

Performance assessment for postgraduate schools

Variously-Transformed Decision Matrix with Weights

	<i>Average book</i> ($\omega_1=0.2$)	<i>Student / staff</i> ($\omega_2=0.2667$)	Research grant ($\omega_3=0.4$)	<i>Graduation delayed</i> ($\omega_4=0.1333$)
<i>School 1</i>	0.5950	1.0000	1.0000	0.0000
<i>School 2</i>	0.6100	0.8333	0.9166	0.7142
<i>School 3</i>	0.6700	0.3333	0.5650	0.4857
<i>School 4</i>	0.6250	0.6666	0.8333	0.2286
<i>School 5</i>	1.0000	0.0000	0.1420	1.0000

Multiple Attribute Value Theory

Additive value function and conditions required

General form of an additive value function is given by:

$$v = \sum_{i=1}^m \omega_i v_i(y_i) = \omega_1 v_1(y_1) + \omega_2 v_2(y_2) + \dots + \omega_m v_m(y_m)$$

Conditions for use of **Additive MAVF**:

1. Satisfaction of *preferential independence* among any groups of attributes. This is only a necessary condition.
2. Satisfaction of the *corresponding trade-off*, or *Thomsen* condition.
3. *Interval scale property* for constructing marginal value function.
4. Weights of attributes need to be assessed as **scaling constants** (trade-offs), or swing weights, not necessarily relative importance.
5. Linear & complete compensation among criteria without any limit.

Additive Value Function Approach

Performance assessment for postgraduate schools

Ranking Using **Variously**-Transformed Decision Matrix

	z^h_1 ($\omega_1=0.2$)	z^f_2 ($\omega_2=0.2667$)	v_3 ($\omega_3=0.4$)	z^e_4 ($\omega_4=0.1333$)	$\sum \omega_i v_i$	Ranking
<i>School 1</i>	0.5950	1.0000	1.0000	0.0000	0.7857	2
<i>School 2</i>	0.6100	0.8333	0.9166	0.7142	0.8061	1
<i>School 3</i>	0.6700	0.3333	0.5650	0.4857	0.5136	4
<i>School 4</i>	0.6250	0.6666	0.8333	0.2286	0.6666	3
<i>School 5</i>	1.0000	0.0000	0.1420	1.0000	0.3901	5

It is useful to conduct **sensitivity analysis** by changing weights, using different normalisation methods or changing value functions.

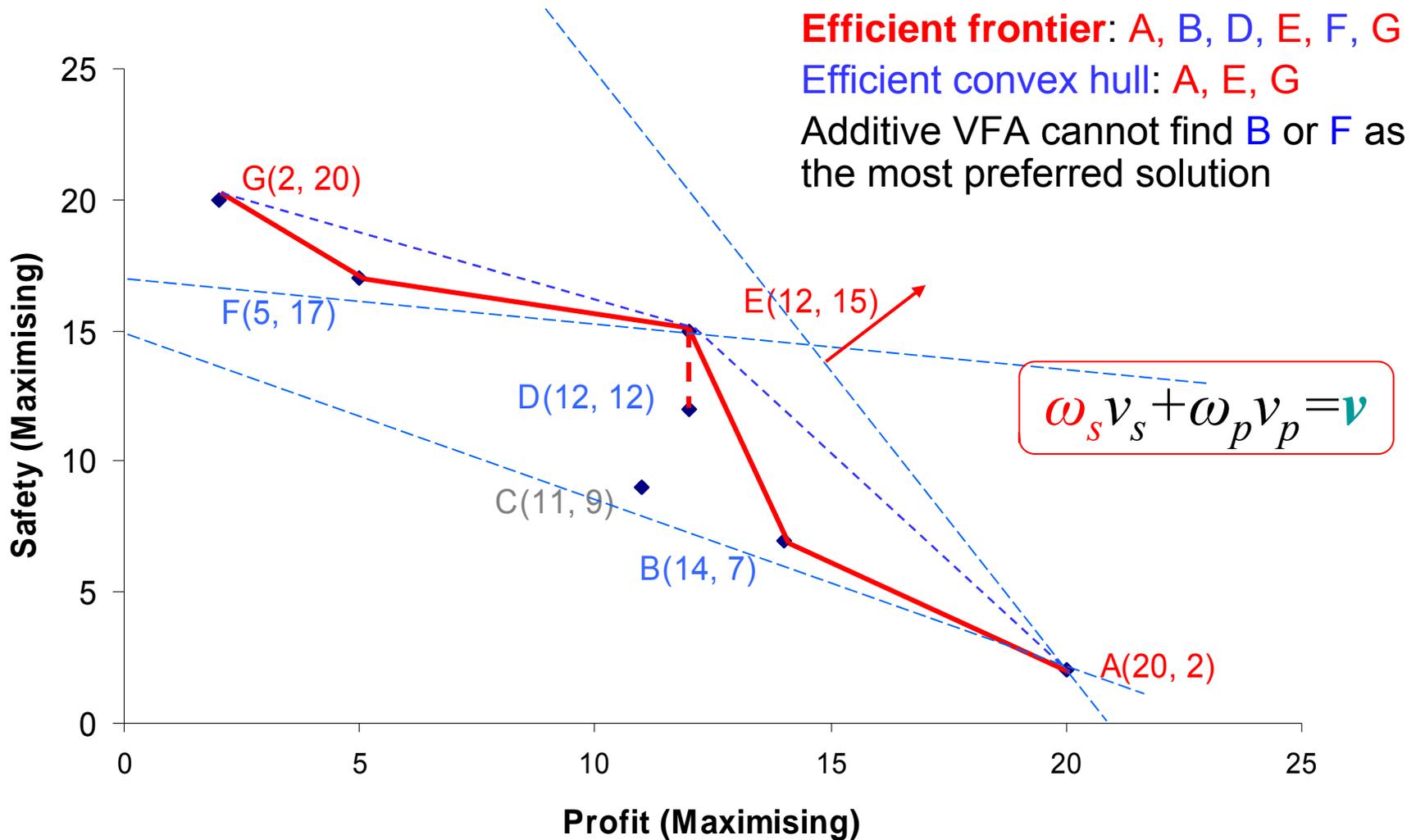
MCDA – Value Measurement Theory

Preferential independence – Violation example

For purchase of MP3 players, suppose **three attributes** are taken into account: *price*, *memory*, and *sound quality*

MP3-A	High price + Large memory	High sound quality
MP3-B	Low price + Small memory	High sound quality
Suppose MP3-A is preferred to MP3-B		
MP3-C	High price + Large memory	Low sound quality
MP3-D	Low price + Small memory	Low sound quality
Would MP3-C still be preferred to MP3-D ?		

Limitation or Bias of Additive VFA



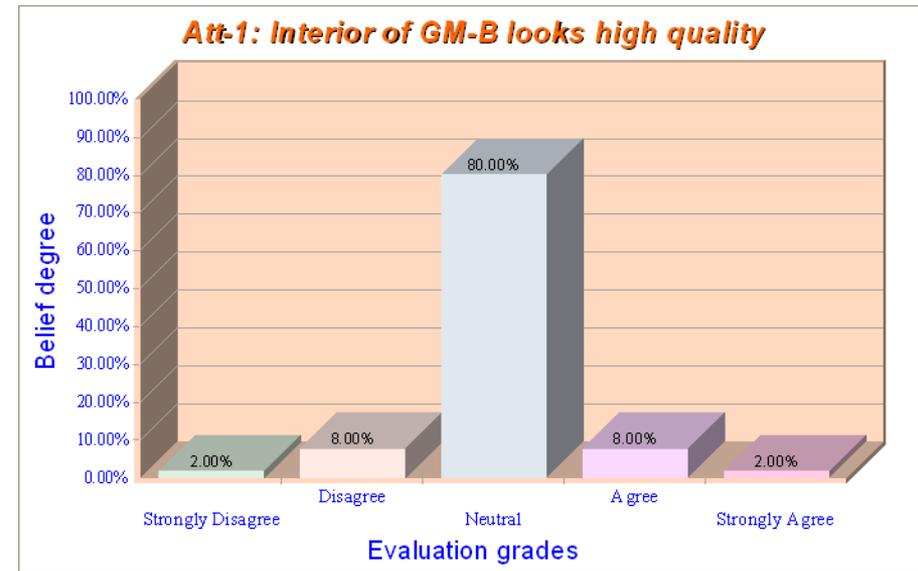
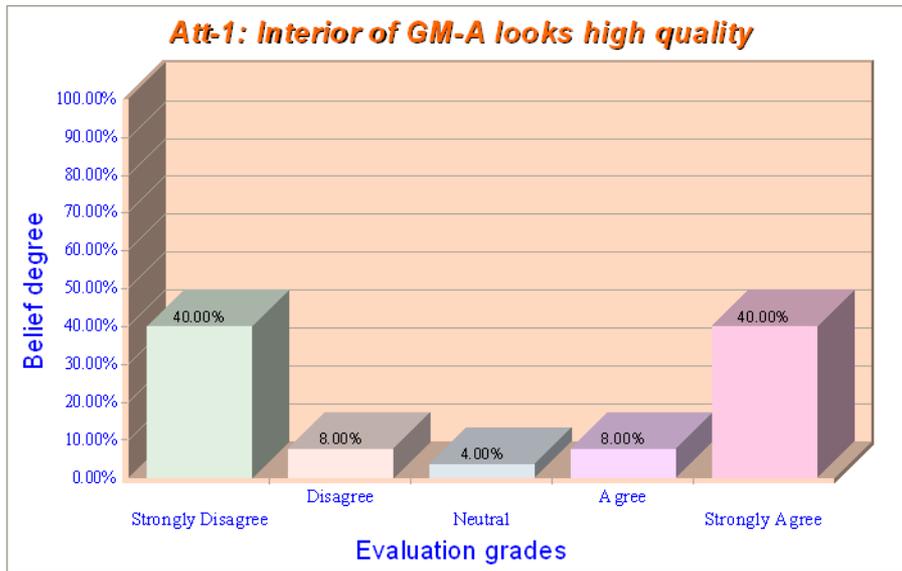
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Multi-Criteria Decision Analysis

Belief distribution versus average assessment

- Frequencies of customer responses from external surveys



- The average score of GM-B is about the same as that of GM-A
- Is GM-B of the same priority to GM as GM-A in future design?

Multi-Criteria Decision Analysis

Belief decision matrix for problem modelling

- **Belief Decision Matrix – Distribution Assessment**

	Attribute 1	Attribute 2	Attribute n
Alternative 1	A_{11}	A_{12}		A_{1n}
Alternative 2	A_{21}	A_{22}		A_{2n}
.....				
Alternative m	A_{m1}	A_{m2}		$A_{mn} = \{(H_1, \beta_1), (H_2, \beta_2), \dots, (H_N, \beta_N)\}$

1. It can represent precise numbers for all criteria on each alternative
2. It can represent subjective judgements
3. It can represent ignorance explicitly

Multi-Criteria Decision Analysis

Belief decision matrix for problem modelling

House Criteria	House 1 in Altrincham	House 2 in Heaton	House 3 in Mercy	House 4 in Didsbury
Location	$\{(G, 0.5), (E, 0.5)\}$	$\{(G, 0.5)\}$	$\{(A, 0.2), (G, 0.8)\}$	$\{(G, 0.2), (E, 0.8)\}$
Distance (mile)	7	5	6	5.5
Asking Price (£)	113,000	110,000	118,000	150,000
Attractiveness	$\{(P, 0.05), (G, 0.35), (E, 0.60)\}$	$\{(A, 0.4), (G, 0.6)\}$	$\{(G, 0.3), (E, 0.7)\}$	$\{(G, 0.6), (E, 0.4)\}$

Construct Qualitative Value Function

Assess the location of houses in south Manchester

Grade	Definition (list of indicators for collecting evidence)
excellent	Pleasant surrounding , Excellent neighbours , First class facilities , Very convenient transportation , Excellent schools , and Many shops around
Good	Good surrounding, Friendly neighbours, Good facilities, Convenient transportation, Good schools, and A number of shops around
Average	Normal surrounding, Ordinary neighbours, Some facilities, Some transportation, Average schools, and A few shops around
Poor	Noisy surrounding, Unfriendly neighbours, Poor facilities, Inconvenient transportation, Poor schools, and Few shops around
Bad	Unbearable surrounding, Terrible neighbours, No facilities, No transportation, No schools, and No shops around

Belief Decision Matrix

Assessment based on evidence collected

IDS Dialog: 1. Altrincham on 1. Location

Grade definitions:

Excellent
Excellent location means
Pleasant surrounding,
Excellent neighbours,
First class facilities,
Very convenient transportation,
Excellent schools, and
Many shops around

Evidence provided:

Surrounding:
The house is part of a small modern development surrounded by mature 1930-built residential houses. It is located at the end of a cul-de-sac of the development.

Neighbours:
They are all private house owners. Most of them are professionals and maintain their gardens regularly. They look friendly.

Facilities:

Provide comments as follows:

From the evidence gathered, it is clear that around this house

Surrounding is pleasant,
Neighbours are friendly,
Facilities are very good,
Transportation is quite convenient,
Schools are excellent, and
there are a number of shops.

So the assessment about the location of the house is
Good to a degree of 0.5 (50%) and
Excellent to a degree of 0.5 (50%).

OK
Cancel
Help
Copy
Paste
Cut
Undo

Assessing the **Location of House 1** in Altrincham using the collected **evidence** against the agreed **assessment standards**

Belief Decision Matrix

Examples for uncertainty modelling

- **From comparing evidence to grading standards**

Supplier 1's performance on Technical Competence

{(Excellent, 50%), (Good, 40%), (Poor, 10%)}

- **Group opinion distribution**

Deep repository on health risk

{(High, 30%), (Medium, 30%), (Low, 40%)}

- **Random data**

Car fuel consumption in mpg (miles/gallon):

{(20mpg, 30%), (22mpg, 30%), (25mpg, 40%)}

Belief Decision Matrix

Examples for uncertainty modelling

- **Judgments from Experience - Personality Test:**

Do you always try to avoid the gaps on pavement?

{(Yes, 20%), (No, 80%)}

- **From converting numerical data to grades**

If Excellent=100, Good=75,

then 90={ (Excellent, 60%), (Good, 40%) }

Belief Decision Matrix

Examples for uncertainty modelling

- **Data with ignorance (partial or complete)**

Car engine quality assessment:

{(Excellent, 30%), (Good, 50%)}

with unknown 20% — Partial ignorance

{(Excellent, 0%), ..., (Poor, 0%)}

with unknown 100% — Complete ignorance

Belief Decision Matrix

Examples for uncertainty modelling

- **Data with interval uncertainties**

Belief assigned to an interval of grades:

{(Excellent-Good), 60%), (Good, 40%)}

- **Interval belief assessed to individual grades:**

{(Moderately Negative, 20-30%),

(Neutral, 30-40%), (Positive, 40-50%)}

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- Multiple criteria assessment and decision analysis problems in real world
- Decision matrix and MCDA explained in graph
- Additive value function approach in MCDA
- Deal with uncertainties in MCDA
- **Evidential reasoning MCDA – concept, model, process and tool**
- A snapshot of real world MCDA applications

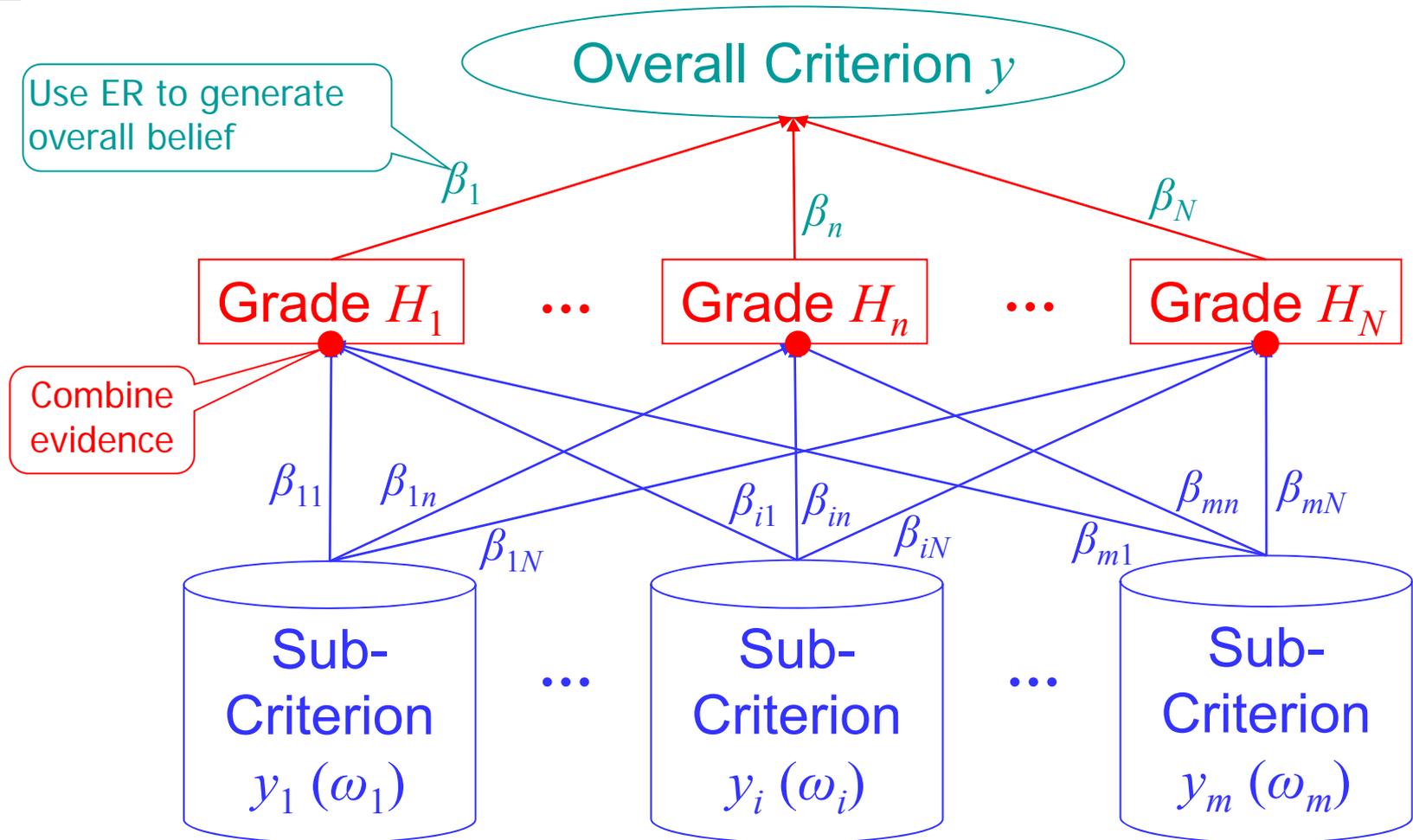
Multi-Criteria Decision Analysis

Belief decision matrix for problem modelling

House Criteria	House 1 in Altrincham	House 2 in Heaton	House 3 in Mercy	House 4 in Didsbury
Location	$\{(G, 0.5), (E, 0.5)\}$	$\{(G, 0.5)\}$	$\{(A, 0.2), (G, 0.8)\}$	$\{(G, 0.2), (E, 0.8)\}$
Distance (mile)	7	5	6	5.5
Asking Price (£)	113,000	110,000	118,000	150,000
Attractiveness	$\{(P, 0.05), (G, 0.35), (E, 0.60)\}$	$\{(A, 0.4), (G, 0.6)\}$	$\{(G, 0.3), (E, 0.7)\}$	$\{(G, 0.6), (E, 0.4)\}$

Evidential Reasoning MCDA

Modelling structure and graphic interpretation



Evidential Reasoning Approach

Framework and algorithm

Step 1: Construct a belief decision matrix

Step 2: Weight assignment and normalised

Step 3: Convert belief to basic probability mass

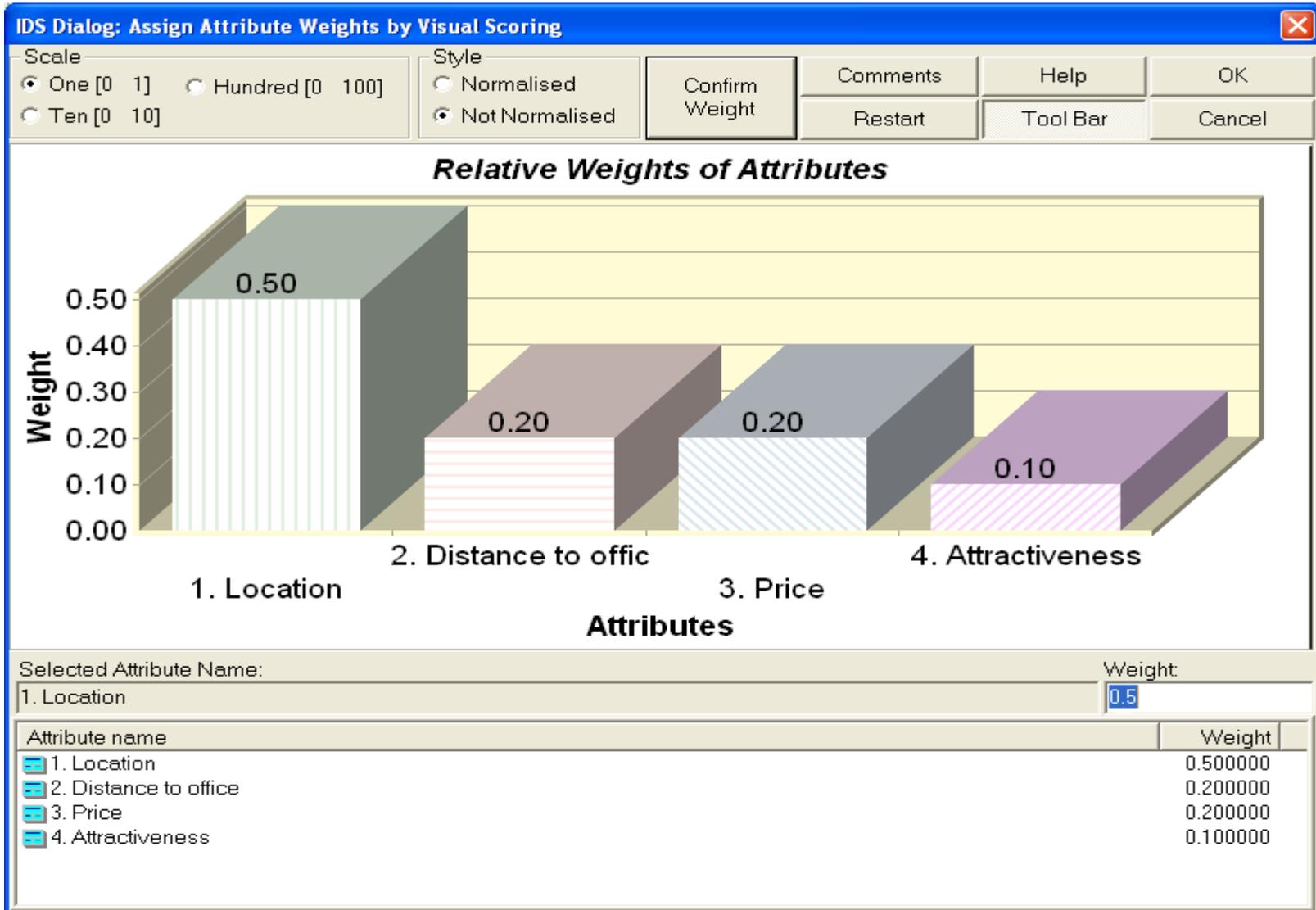
Step 4: Combine basic probability mass

Step 5: Generate combined distribution assessment

Step 6: Utility function based alternative ranking

Directly assigning criterion weights

The house purchase example



Assigning weights by Comparisons

The house purchase example

IDS Dialog: Assign Weights Using Pairwise Comparisons

For the following father attribute
 House selection

Compare the relative importance of a selected child attribute with the other child attributes in the following pairwise fashion

Attribute Selected: 1. Location is 5 times as important as Attribute Compared to: 4. Attractiveness

Buttons: Confirm selection, Help, OK, Confirm comparison, Comments, Cancel

Weight generation method:
 Geometric Mean
 Eigenvector (AHP)
 Mixed Approach

Calculate weights

Generated Weights:

Attribute name	Weight
1. Location	0.500000
2. Distance to office	0.200000
3. Price	0.200000
4. Attractiveness	0.100000

Provided Pairwise Comparisons:

Attribute Selected	times a.i.a.	Attribute Compared to
1. Location	2.500000	2. Distance to office
1. Location	2.500000	3. Price
1. Location	5.000000	4. Attractiveness

Buttons: Clear all comparisons, Inconsistency Index: 0, Advice

Evidential Reasoning MCDA

The evidential reasoning algorithm

Generation of overall belief:

β_n can be generated by using the following nonlinear evidential reasoning algorithm:

$$\beta_n = k \left[\prod_{i=1}^m (\omega_i \beta_{i,n} + 1 - \omega_i) - \prod_{i=1}^m (1 - \omega_i) \right]$$

$$k = \left[\sum_{n=1}^N \prod_{i=1}^m (\omega_i \beta_{i,n} + 1 - \omega_i) - N \prod_{i=1}^m (1 - \omega_i) \right]^{-1}$$

$$S = \{(H_n, \beta_n), n = 1, \dots, 5\}$$

ER-MCDA and Condition to Use *Judgmental independence*

An attribute is judgementally independent of other attributes if the assessment of the former does not depend on the assessment of the latter as long as they are fixed.

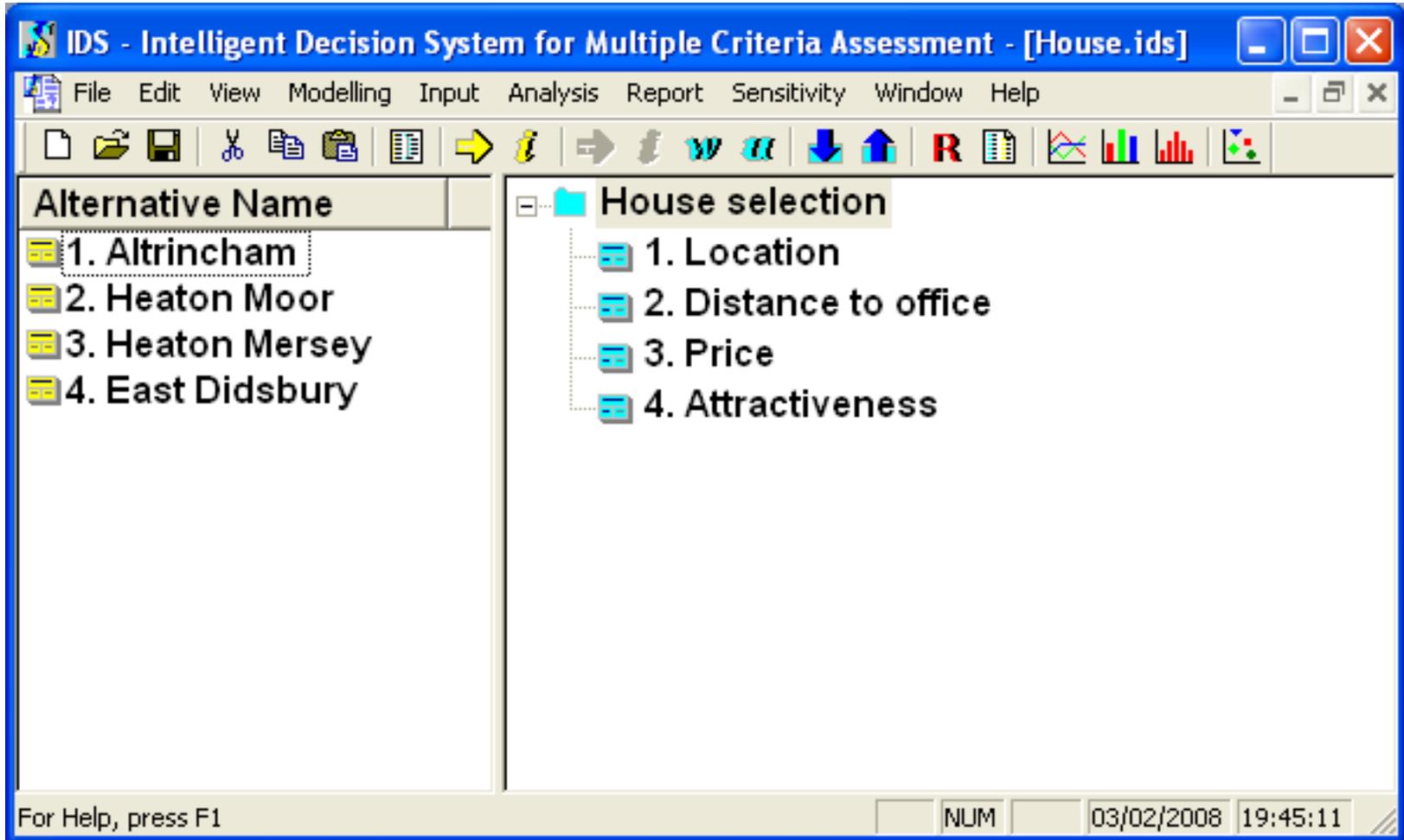
For example, for purchase of MP3 players, suppose only two attributes *price* and *sound quality* are taken into account. It is then commonly accepted that

- 1 – For any fixed price, high sound quality MP3 is judged to be better
- 2 – For any fixed sound quality, low price MP3 is judged to be better

So, the two attributes *price* and *sound quality* are mutually **judgementally independent**, though they may be correlated.

Buy house – IDS Main Interface

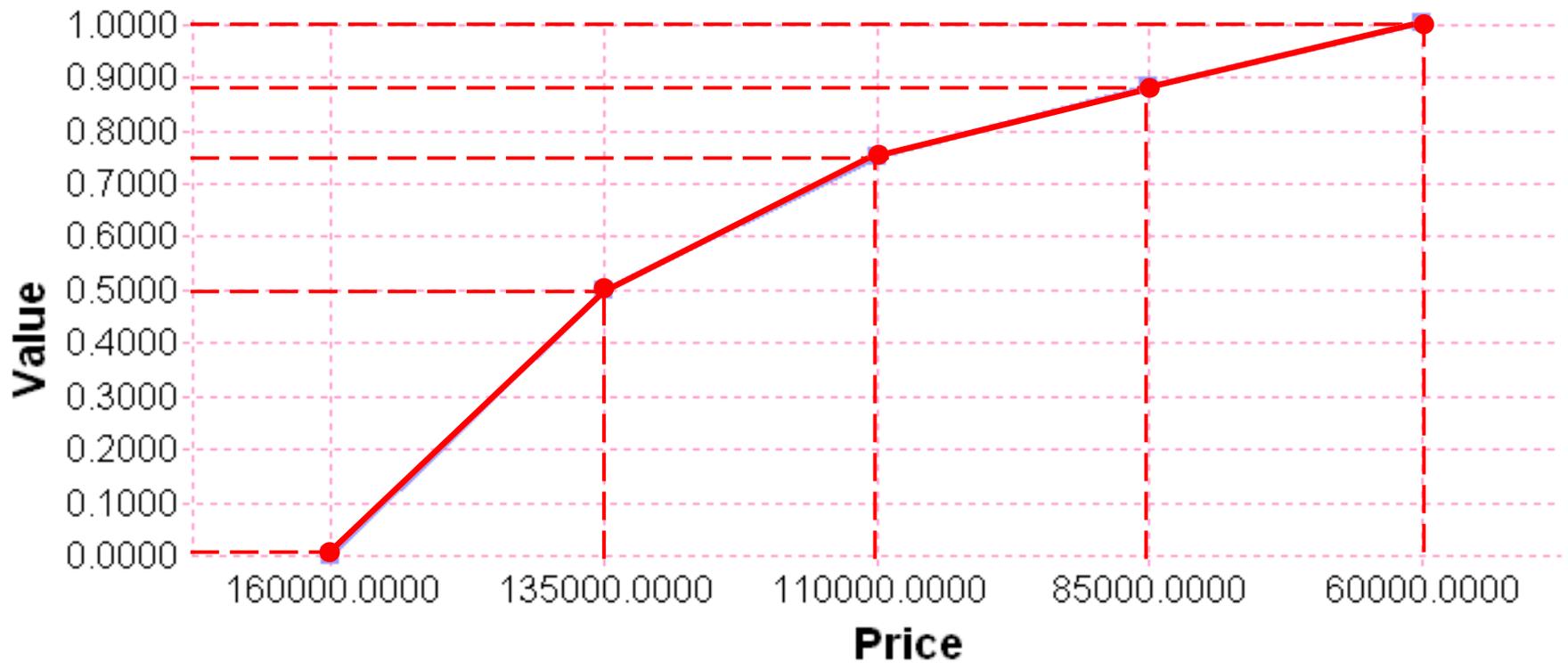
Assessment hierarchy and alternative houses



Assess a partial value function

Direct assessment method

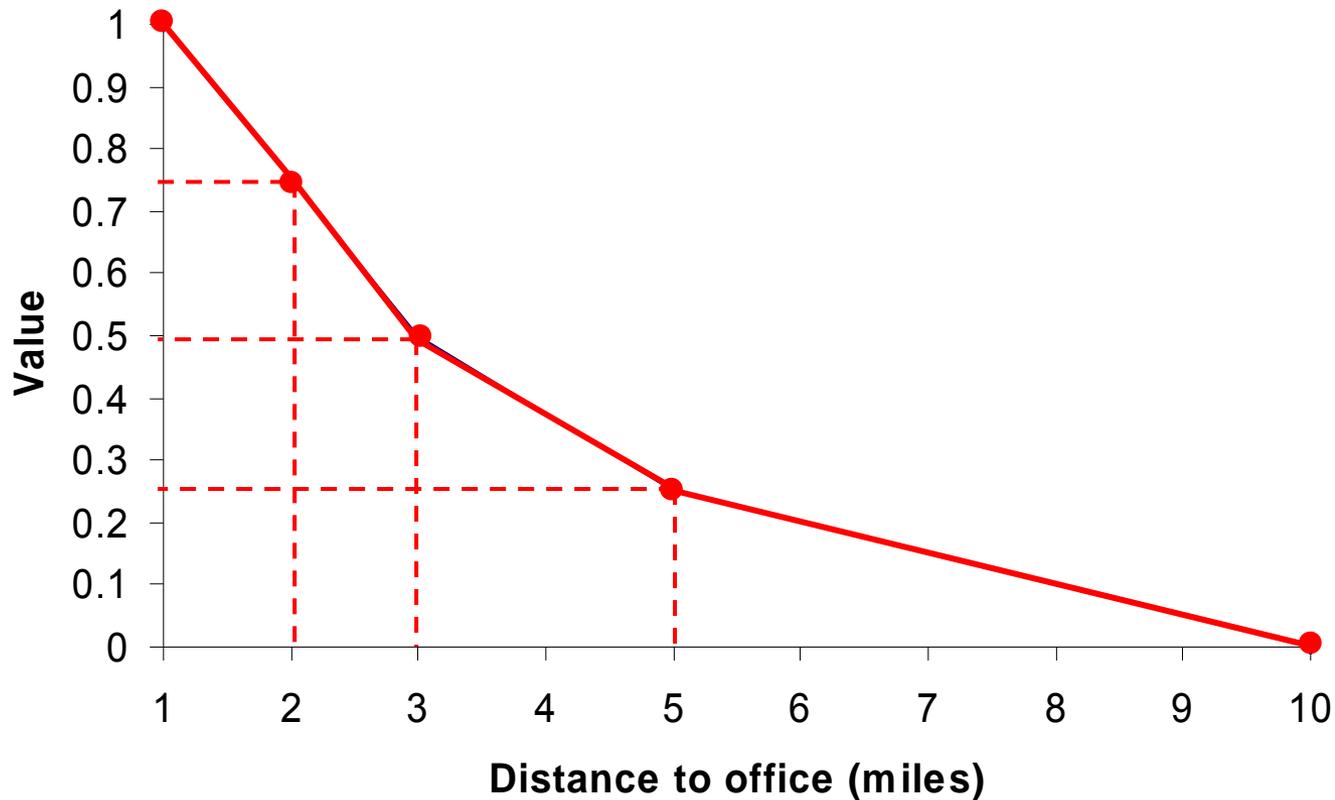
The marginal value function of the price



Assess a partial value function

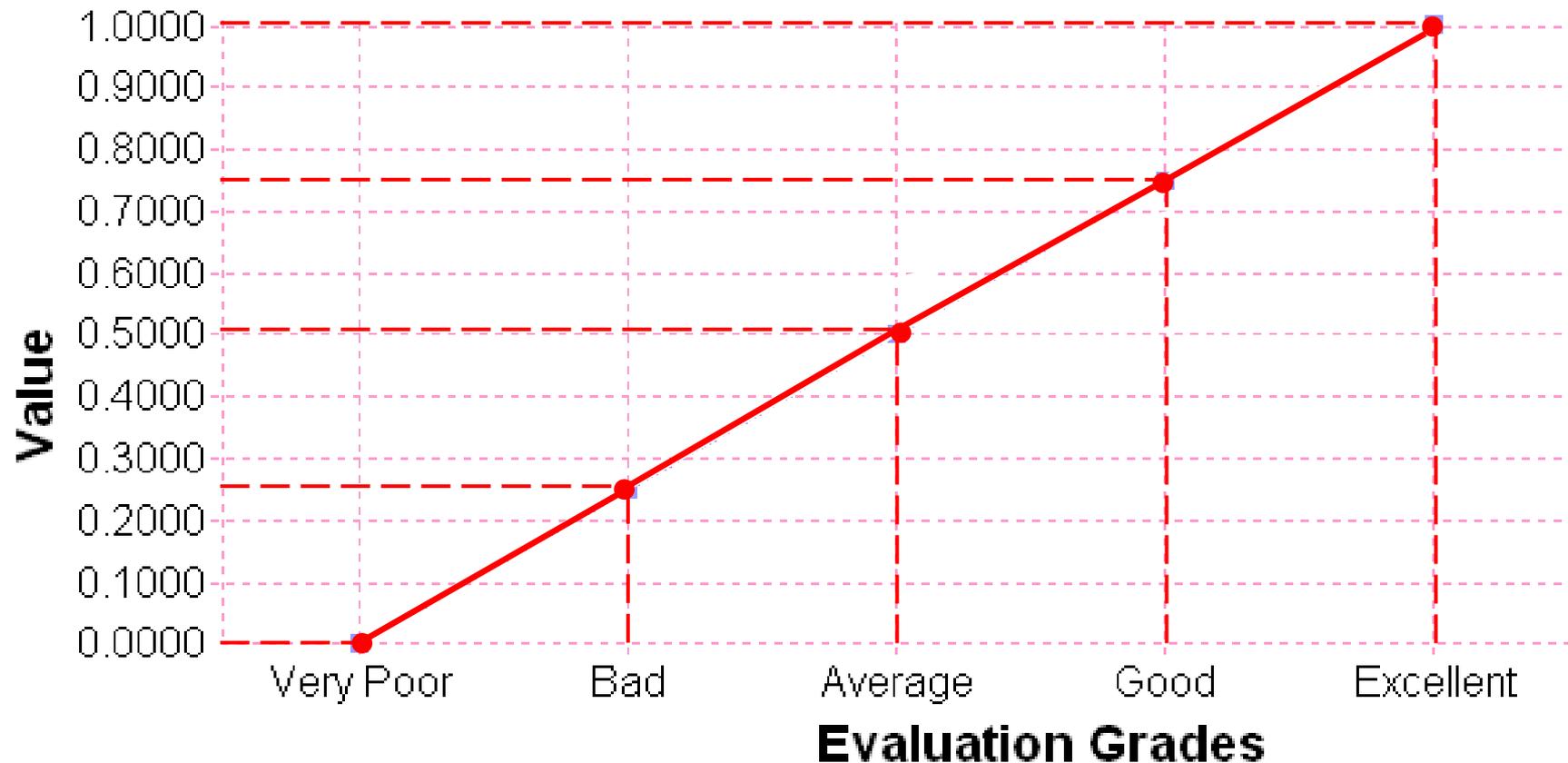
Bisection assessment method

The marginal value function of the distance to office

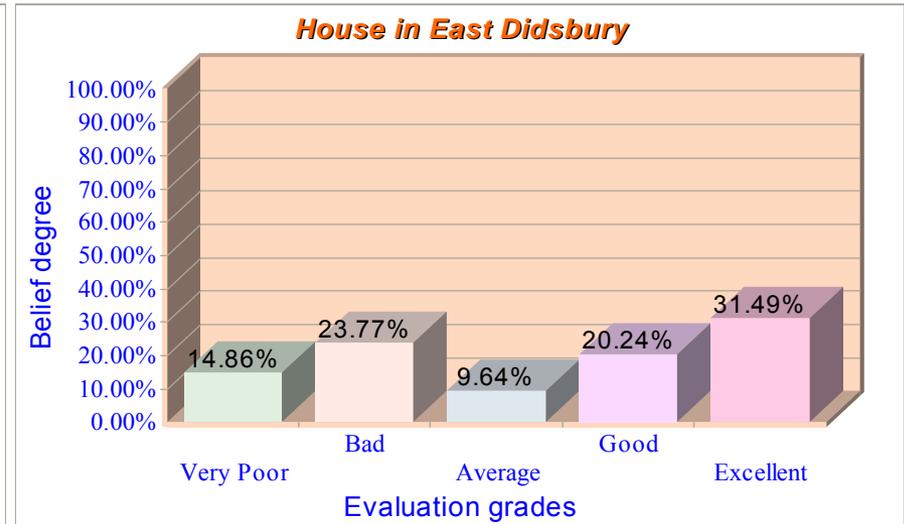
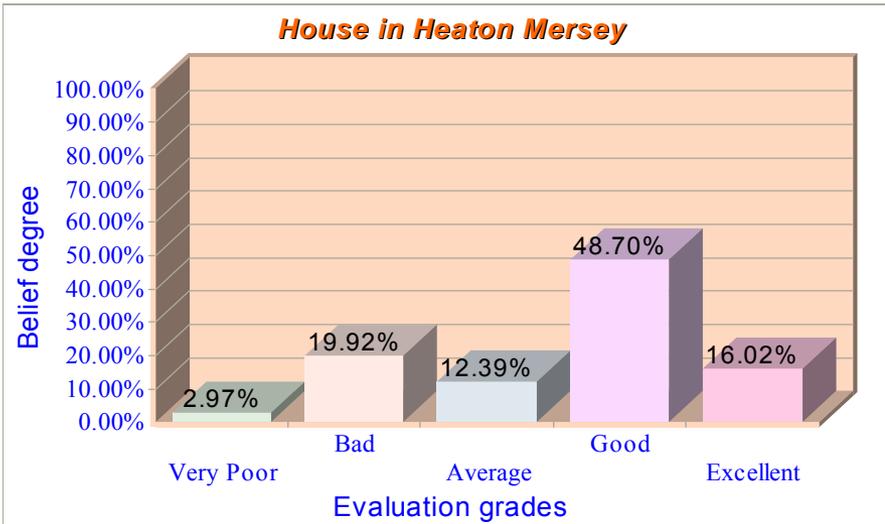
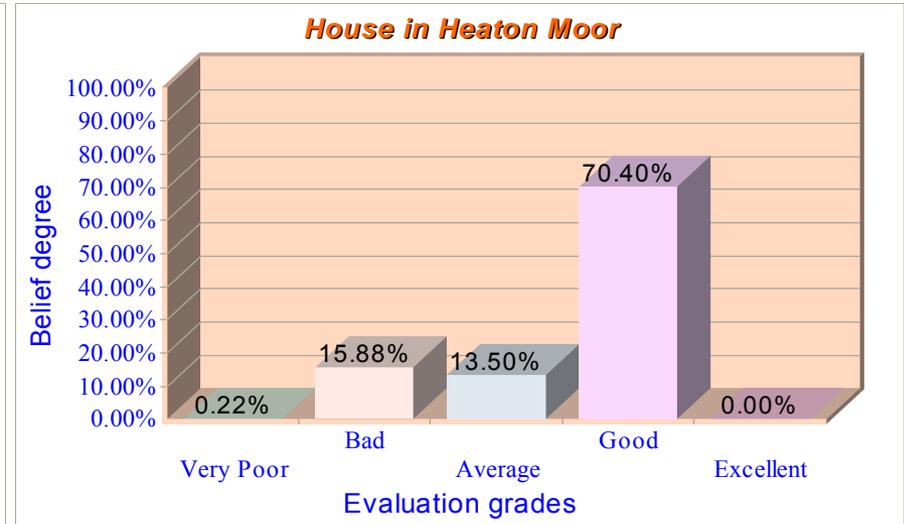
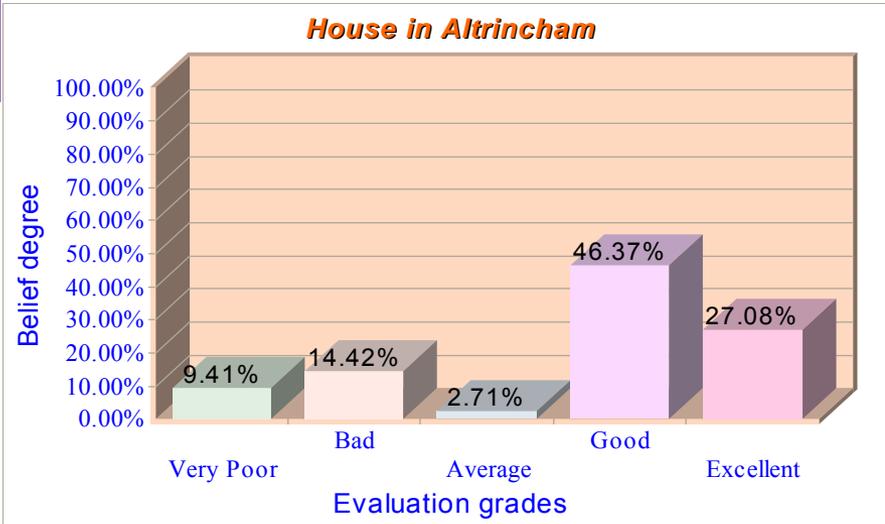


Example 2: Buy house

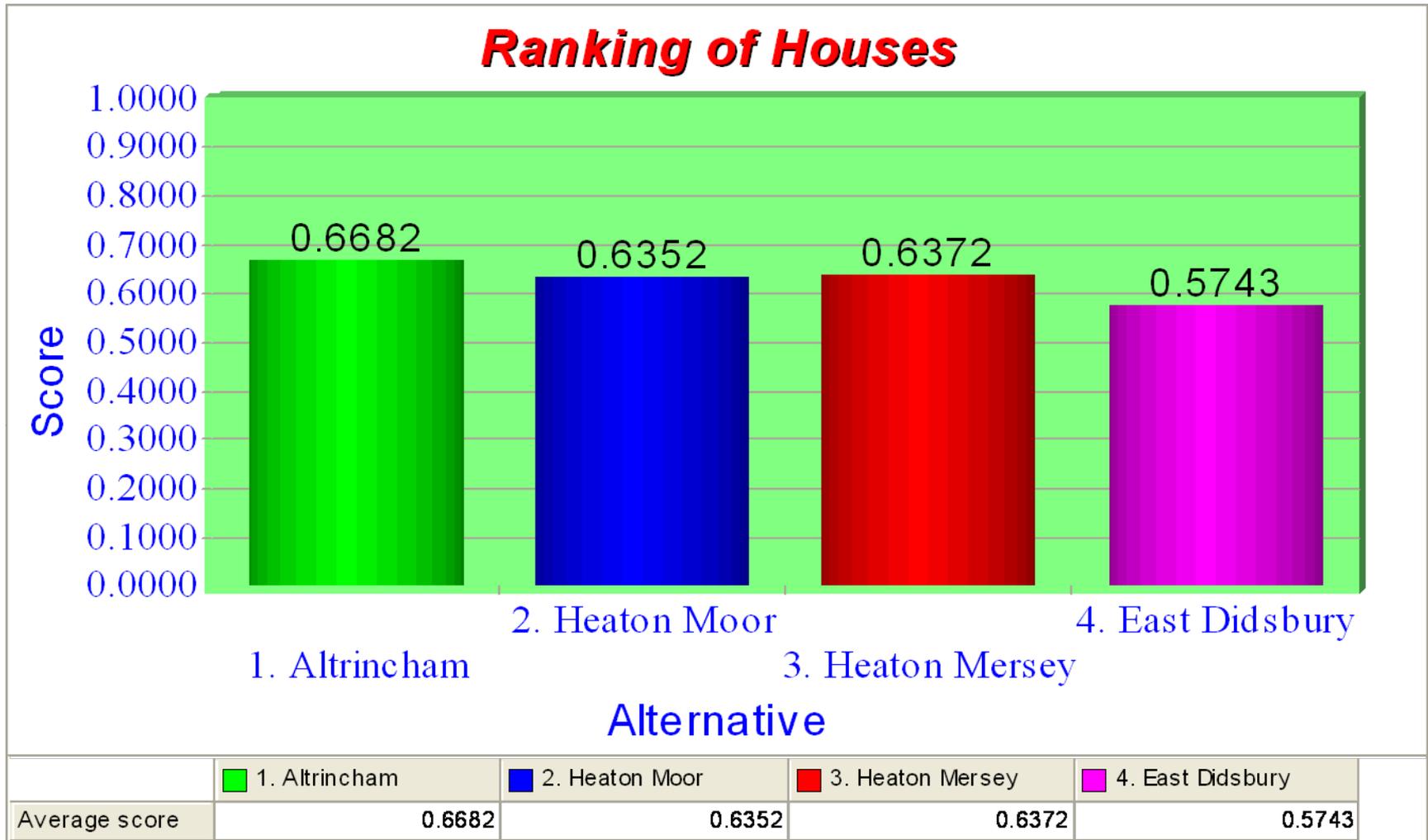
Assess value functions for other attributes



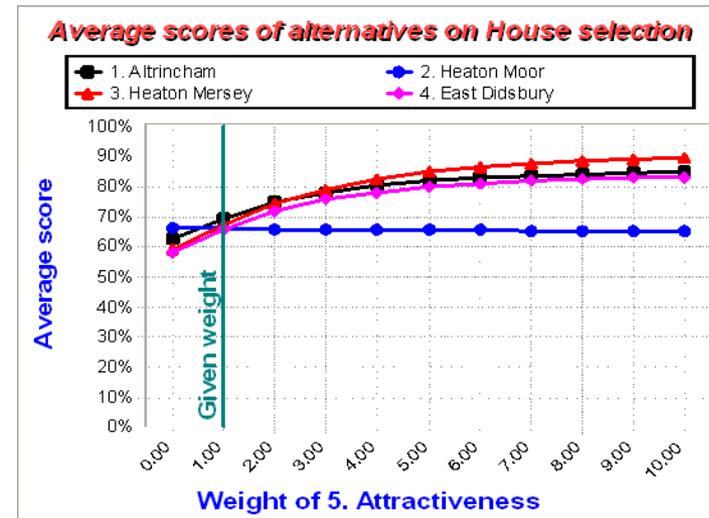
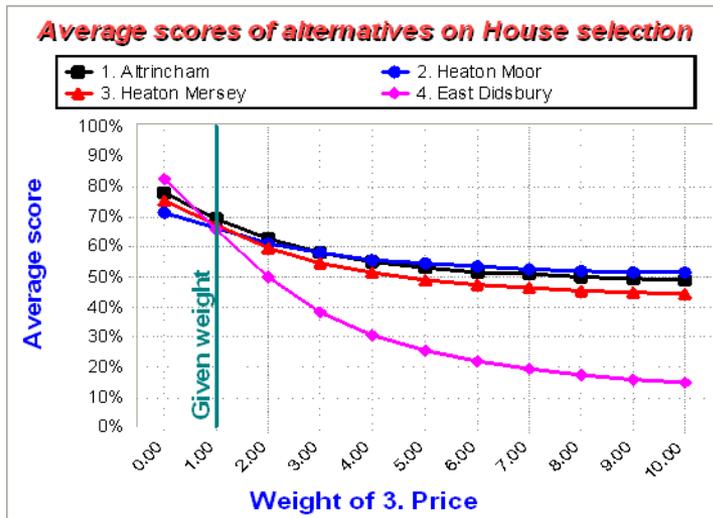
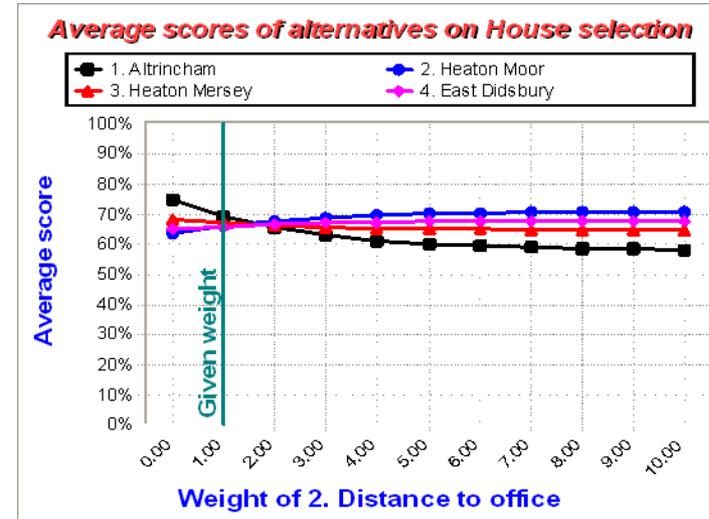
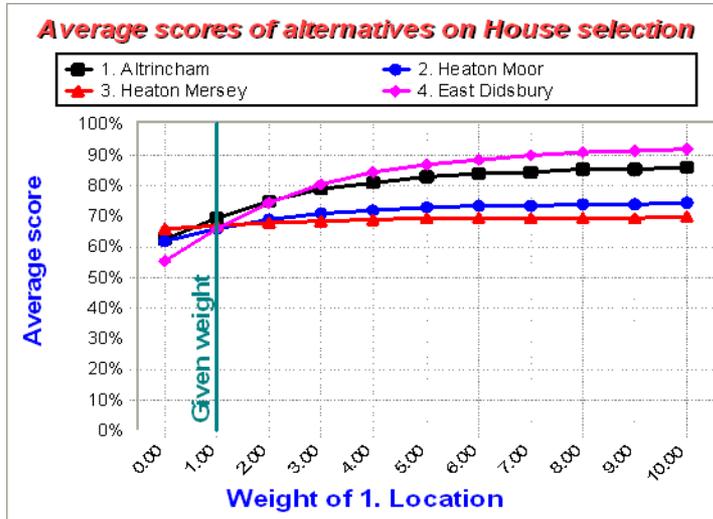
Distributed Assessments of Four Houses



Rank Order of the Four Houses



Sensitivity of the Ranking of Houses



Main Topics of the Session

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MCDA Applications in Real World

Example 3: Motorbike performance assessment hierarchy

IDS - Intelligent Decision System for Multiple Criteria Assessment - [Motorcycle.ids]

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Alternative Name

- Kawasaki
- Yamaha
- Honda
- BMW

Motorcycle selection

- Price
- Displacement
- Range
- Top speed
- Engine Performance
- Operation Quality
- General finish
 - Quality of finish
 - Seat comfort
 - Headlight
 - Mirrors
 - Horn

J. B. Yang, "Rule and utility based evidential reasoning approach for multiple attribute decision analysis under uncertainty", *European Journal of Operational Research*, Vol. 131, No.1, pp.31-61, 2001.

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MCDA Applications in Real World

Example 4: Organisational quality self-assessment

Alternative Name

- UUSD 2002
- ND 2000
- Corning 2000
- Vertex 2001
- NWW 2000

M. Li and J. B. Yang, "A decision model for self-assessment of business process based on the EFQM excellence model", *International Journal of Quality and Reliability Management*, Vol.20, No.2&3, pp.163-187, 2003

EFQM Self-assessment

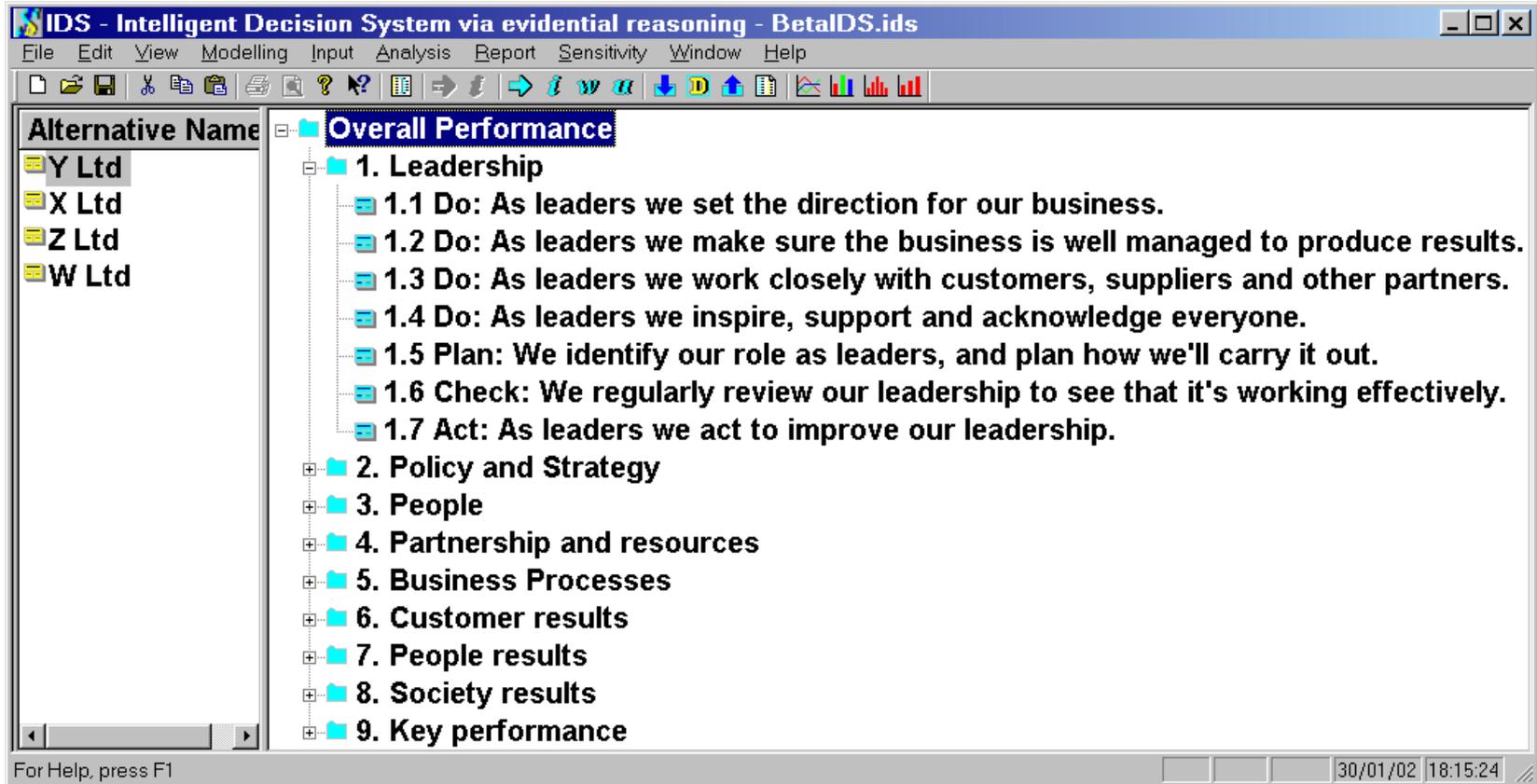
- Enablers
 - 1 Leadership
 - 2 Policy and Strategy
 - 3 People
 - 4 Resources and Partnerships
 - 5 Processes
 - 5a Processes are systematically designed and managed
 - 5b Processes are improved
 - 5c Products and Services are designed and developed
 - 5d Products and Services are produced, delivered and serviced
 - 5e Customer relationships are managed and enhanced
- Results
 - 6 Customer Results
 - 7 People Results
 - 8 Society Results
 - 9 Key Performance Results

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MCDA Applications in Real World

Example 5: Performance assessment for SME



D. L. Xu and J. B. Yang, "[Intelligent decision system for self-assessment](#)", *Journal of Multiple Criteria Decision Analysis*, Vol.12, 43-60, 2003.

MCDA Applications in Real World

Example 6: Company innovation capability assessment

Alternative Name

- Below average com...
- Average company
- Above average co...
- Excellent company
- X Limited

D. L. Xu, G. McCarthy and J. B. Yang, "Intelligent decision system and its application in business innovative capability assessment", *Decision Support Systems*, Vol.42, pp.664-673, 2006.

Company Profile

- Level of Innovation
- Innovation Strategy
- Innovation Process
- People and Culture
 - 1. Does the company find it easy to attract talented applicants when it recruits
 - 2. How well does the company motivate talented people?
 - 3. Does the company retain the people it wants to keep?
 - 4. Does the company have the competencies in-house which it needs?
 - 5. Are employees encouraged to learn and develop new skills?
 - 6. Are employees empowered to test new ideas?
 - 7. Are people given time and resources to develop ideas?
 - 8. Is creativity recognised and rewarded?
 - 9. Does regular internal communication reach:
 - 10. Are the leaders willing to accept other people's ideas?
 - 11. Is there an acceptance in the company that developing new ideas may ent
 - 12. Is there an awareness of the culture of other companies, e.g. customers, pa
 - 13. the company structure appropriate for the planned level of innovation, e.g.
- Financial Resources
- Knowledge and Information and Communication Technology (ICT)
- Business Networks

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MCDA Applications in Real World

Example 7: R&D project performance assessment

IDS - Intelligent Decision System for Multiple Criteria Assessment - [(whole company)jac.ids]

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Alternative Name

- Light Trailer
- Heavy Trailer
- MVP
- SRV

X. B. Liu, M. Zhou, J. B. Yang and S. L. Yang, "Assessment of strategic R&D projects for car manufacturers based on the evidential reasoning approach", *International Journal of Computational Intelligence Systems*, Vol.1, 2007.

R&D product assessment system

- Quality of production
 - scale and importance
 - level of technique
 - complexity of critical technique
 - ratio between quality and price
 - reliability of product
 - economy
 - theoretical value and level of innovation
- Process control
 - quality of project
 - finishing time
 - investment
- Added results
 - project team
 - continuity of technique

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MCDA Applications in Real World

Example 8: Customer satisfaction survey & assessment

Alternative Name

- Customer 1
- Customer 2
- Customer 3
- Customer 4
- Customer 5
- Customer 6
- Customer 7
- Customer 8
- Customer 9
- Customer 10
- Customer 11
- Customer 12
- Customer 13
- Customer 14
- Customer 15
- Customer 16
- Customer 17
- Customer 18
- Customer 19
- Customer 20
- Customer 21
- Customer 22
- Group of 22 Customers

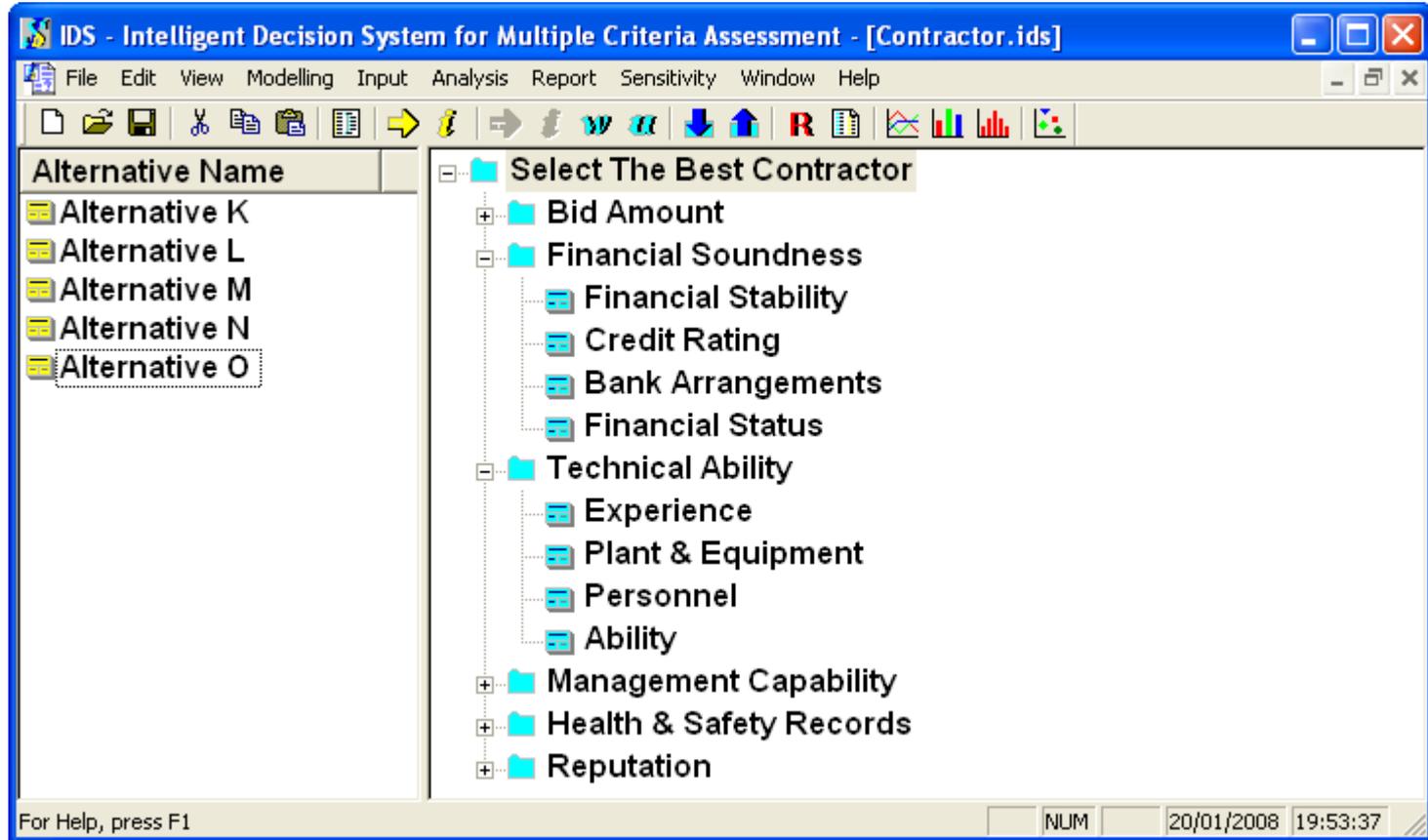
Performance & Service Survey

- Section 1: Service
 - 1. What is your perception of the service you receive from Silcoms?
 - 2. How satisfied are you with the level of service provided by Silcoms personnel?
 - 3. Is the response to manufacturing problems or quality issues to your company?
 - 4. How accessible are Silcoms personnel to your company?
 - 5. Is the communication flow between yourselves and Silcoms personnel?
 - 6. Is the flexibility of Silcoms personnel to your production demands?
 - 7. Is the advice and support you receive from Silcoms personnel?
 - 8. At the start of any new product, how proactive are Silcoms personnel?
 - 9. Is the standard of technical documentation provided by Silcoms?
- Section 2: Quality
- Section 3: Cost/Sales
 - 1. Do you believe you receive value for money for Silcoms products?
 - 2. Is the response to your initial enquiry?
 - 3. Is the costing information provided by Silcoms?
 - 4. Is the response time for providing costing information?
 - 5. Do Silcoms meet your costing targets?
 - 6. What is your opinion of the sales service provided by Silcoms?
 - 7. What is your opinion of the after sales service provided by Silcoms?
- Section 4: Delivery

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MCDA Applications in Real World

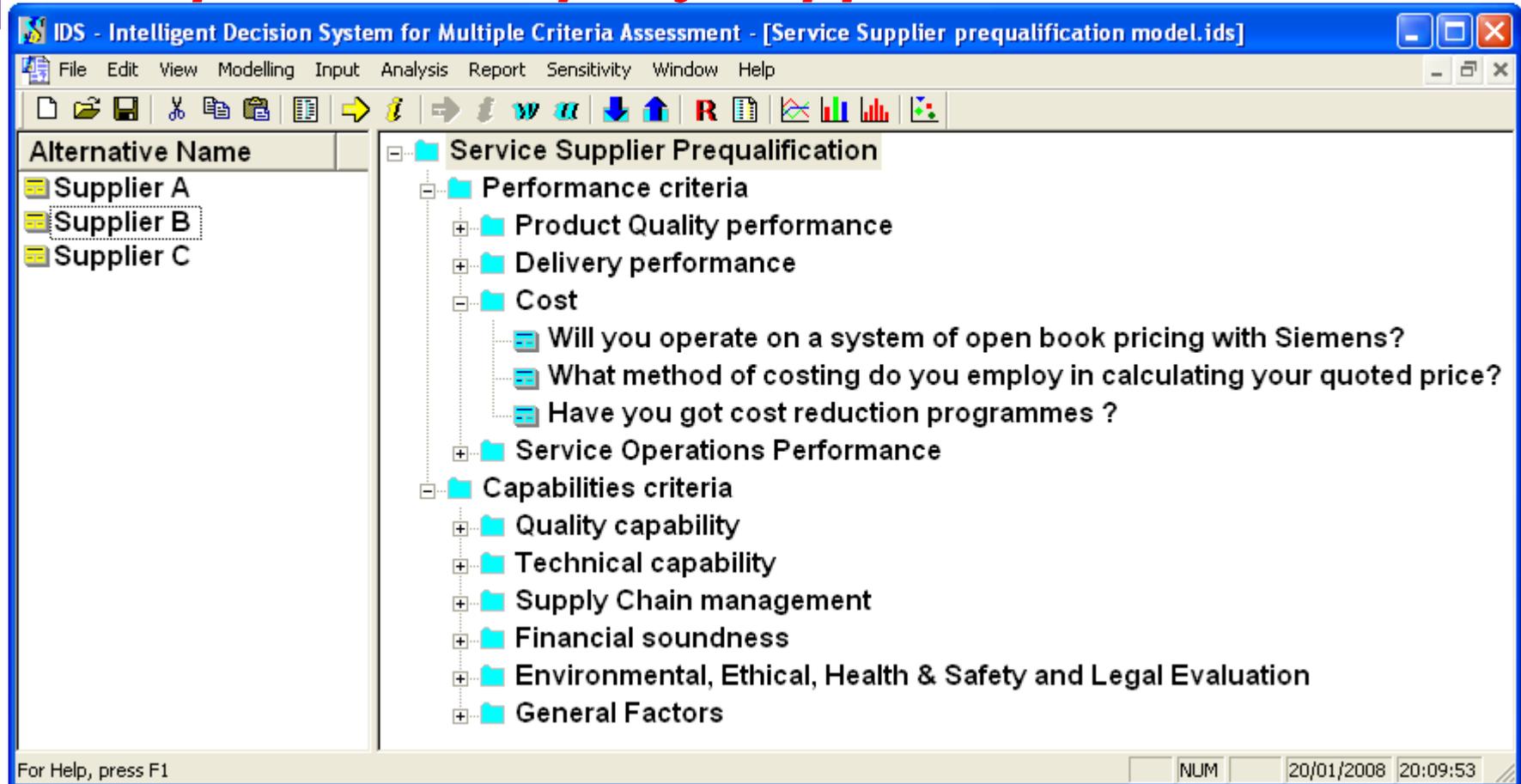
Example 9: Selection of construction contractors



M Sonmez, G. Graham and J. B. Yang and G D Holt, "[Applying evidential reasoning to pre-qualifying construction contractors](#)", *Journal of Management in Engineering*, Vol.18, No.3, pp.111-119, 2002.

MCDA Applications in Real World

Example 10: Company supplier selection



Joanna Teng "[Development of a supplier prequalification model for Siemens UK](#)", *MSc Dissertation, Manchester School of Management, UMIST, 2002*

MCDA Applications in Real World

Example 11: Environmental impact assessment

IDS - Intelligent Decision System for Multiple Criteria Assessment - [EIA1.ids]

File Edit View Modelling Input Analysis Report Sensitivity Window Help

Alternative Name

- 1. No action
- 2. Building a high dam
- 3. Building a smaller, high dam
- 4. Building sedimentation reservoir

Y. M. Wang, J. B. Yang and D. L. Xu,
"Environmental Impact Assessment
Using the Evidential Reasoning
Approach", *European Journal of
Operational Research*, Vol.174, No.3,
pp.1885-1913, 2006.

Conservation of Rupa Tal (Lake of Beauty) of Nepal

- Physical/Chemical (P/C)
 - P/C1: Changes in lake water volume
 - P/C2: Changes in the lake sedimentation
 - P/C3: Changes in crop and grazing areas
- Biological/ecological (B/E)
 - B/E1
 - B/E2
 - B/E3
 - B/E4
 - B/E5
- Sociological/cultural (S/C)
- Economic/operational (E/O)

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