



Graphical and technical options in Expert Choice for group decision making

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Barfod, M. B. (Ed.) (2014). *Graphical and technical options in Expert Choice for group decision making*. (1 ed.) DTU Transport.

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Graphical and technical options in Expert Choice for group decision making



DTU Transport Compendium Series part 3

Version 2014

Graphical and technical options in Expert Choice for group decision making

DTU Transport Compendium Series part 3

Department of Transport, Technical University of Denmark

First Edition, 2014

Edited by: Michael Bruhn Barfod

Frontpage: Photo by Colourbox

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Abbreviations

Abbreviation	Full name
AHP	Analytic Hierarchy Process
CBA	Cost-Benefit Analysis
DSS	Decision Support System
MCDA	Multi-Criteria Decision Analysis

1 Introduction

Decision support systems (DSS) are widely applied to assist decision-makers with the difficult task of identifying the best solution to a given problem. The most common methodology applied so far to the evaluation of transport systems has been conventional cost-benefit analysis (CBA), which supported by traffic- and impact model calculations provides the decision-makers with a monetary assessment of the project's feasibility.

Internationally seen there has been a growing awareness over the recent years that besides the social costs and benefits associated with transport other impacts that are more difficult to monetise should also have influence on the decision making process. This is in many developed countries realised in the transport planning, which takes into account a wide range of impacts of also a strategic character. It is commonly agreed that the final decision making concerning transport infrastructure projects in many cases will depend on other aspects besides the monetary ones assessed in a socio-economic analysis.

A coherent, well-structured, flexible, straight forward evaluation method, taking into account all the requirements of a transport infrastructure project is for this reason required. An appropriate ex-ante evaluation method for such projects can be based on multi-criteria decision analysis (MCDA). The use of MCDA in a decision process usually provides some or all of the following features:

- Improvement of the satisfaction with the decision process
- Improvement of the quality of the decision itself
- Increased productivity of the decision-makers

MCDA can in this respect be seen as a tool for appraisal of different alternatives, when several points of view and priorities are taken into account to produce a common output. Hence, it is very useful for the formulation of a DSS designed to deal with complex issues. The literature on MCDA is extensive, providing a sound basis for the methodologies employed and the mathematics involved. Moreover, there are numerous systems covering several disciplines, policy contexts and users' needs for specific application environments.

This compendium examines the Expert Choice DSS based on the well-known MCDA technique: the analytic hierarchy process (AHP). More specifically, the possibilities for using the Expert Choice software in decision situations involving groups are examined with focus on the graphical presentations of the DSS.

2 The Expert Choice software

The Expert Choice software is a multi-objective decision support tool based on the Analytic Hierarchy Process (AHP), a mathematical theory first developed at the Wharton School of the University of Pennsylvania by one of Expert Choice's founders, Thomas Saaty (1977). The AHP is a powerful and comprehensive methodology designed to facilitate sound decision making by using both empirical data as well as subjective judgments of the decision-maker(s).

The AHP assists with the decision making process by providing decision-makers with a structure to organize and evaluate the importance of various objectives and the preferences of alternative solutions to a decision.

Following are the steps used in AHP and Expert Choice:

- Brainstorm and structure a decision problem as a hierarchical model
- Set the type and mode of pair wise comparisons or data grid functions
- Group enable the model
- Import data to Expert Choice from external databases
- If applicable, pair wise compare the alternatives for their preference with respect to the objectives, or assess them using one of the following: ratings or step functions, utility curves, or entering priorities directly
- Pair wise compare the objectives and sub-objectives for their importance to the decision
- Synthesize to determine the best alternative
- Perform sensitivity analysis
- Export data to external databases
- To perform resource allocations using Expert Choice's 'Resource Aligner' to optimize alternative projects subject to budgetary and other constraints

Expert Choice has a unique method of using pair wise comparisons to derive priorities that can more accurately reflect perceptions and values than most other ways. Expert Choice synthesizes or combines the priorities that are derived for each facet of the problem to obtain the overall priorities of the alternatives. By performing "what-if" and sensitivity analyses, it can quickly be determined how a change in the importance of an objective would affect the alternatives of choice.

If the results of the decision model differ from the decision-makers' intuition it is possible to modify the model and/or judgments until the model incorporates this intuition. Then the model results will either change to conform to the "gut" feeling, or the intuition will change based upon the modelling. In the former case, not only the "gut" feeling will be verified, but a detailed justification will be available if one is required. In the latter case, the decision-makers will have learned something and avoided a costly mistake.

Expert Choice provides for the synthesis of different peoples' judgments. Expert Choice is also useful for forecasting, assessing risk and uncertainty, and deriving probability distributions.

These are some of the features available in Expert Choice:

- User friendly displays that make decision model building straightforward and simple
- 'ModelView' containing one of the following:
 - 'TreeView' pane – a hierarchy of objectives, plus the 'Alternatives' and rich text end-user documentation in the form of 'Information Documents'
 - 'Affinity Diagramming' pane – a presentation of the decision hierarchy (objectives, sub-objectives) plus alternatives and information documents
 - Pros and cons associated with a selected alternative, the alternatives and information documents
- 'TreeView' with automatic expansion and collapsing of branches including:
 - Long objectives/names of the criteria to allow for in-depth explanations
 - Drag and drop manipulation of objectives and sub-objectives in the 'TreeView' or 'Affinity Diagramming'
 - Unlimited levels in the hierarchy – build larger, more complex decision models
- 'Information Documents' – easily accessible from most windows, enabling the possibility to import videos, sound or text or even run other programs
- 'Notes' – another form of documentation, where each group participant can enter their own comments related to the decision process
- 'Data Grid' approaches
 - 'Ratings'
 - 'Step Functions'
 - 'Increasing and Decreasing Utility Curves'
 - 'Direct Entry of Priorities'
 - 'User Defined Columns'
 - 'Data Conversion' – ability to rapidly convert large amounts of raw data from existing databases to prioritised information to be used for decision-making
- 'Resource Aligner' – ability to optimize resources and allocate funds (budgets) with varying constraints, groups, funding pools and risks (this function is not described further in this report, see Expert Choice (2004))
- 'Printing/Reporting' – easily exportable reports to Microsoft Word and Excel (this function is not described further in this report, see Expert Choice (2004))
- 'Network' capabilities for group decision-making including Expert Choice's 'Decision Portal' using a browser

- ‘Reply System Receiver’ and ‘Keypad’ capability for group decision making
- ‘Resource Allocation’ – a way to select a combination of alternatives that maximise (optimise) the attainment of objectives while not exceeding a specified budget – available as an Expert Choice add on (this function is not described further in this report, see Expert Choice (2004))

Moreover, Expert Choice helps participants in a group to define objectives, sub-objectives and alternatives and then organize them into a structured hierarchical tree. Once participants compare and prioritise the relative importance of the decision objectives, Expert Choice is then used to synthesize the group's judgments to arrive at a conclusion. Then the team can examine how changing the priorities of any objective affects the outcome by manipulating one of four dynamic sensitivity graphs. By keeping the participants focused on the problem, Expert Choice contributes to more efficient use of meeting time.

In addition to the features described above Expert Choice is a decision-support software tool designed to help groups enhance the quality of their decisions by bringing structure to the decision making process. It enables group members any place in the world to solve decisions together through the Internet using their own network. Expert Choice's ‘Decision Portal’ provides web capability and works as a virtual meeting place allowing for each participant's input to be officially heard and included in the final decision. This not only reinforces buy-in from all members but also saves on travel time and costs.

If Expert Choice is keypad enabled it is possible to create a group decision room where members of the team can brainstorm and answer questionnaires. Then the results can be structured into a decision hierarchy. Using electronic keypads, up to 150 people can make judgments about the objectives or sub-objectives and alternatives of a decision problem. This function is unfortunately not supported by the type of keypads that are the property of DTU Transport, and has for this reason not been tested further.

The remaining part of this report is structured as follows. Chapter 2 provides a review of the model functions in Expert Choice including their graphical presentations. Chapter 3 takes the basic functions a step further and elaborates over the possibilities to combine group judgments in the software. Chapter 4 gives a conclusion and perspective of the possibilities of Expert Choice.

The case study of the Helsingør-Helsingborg (HH) connection will be used for illustration throughout the report. For more information about the case study see Larsen and Skovgaard (2010). This relatively simple model has only five objectives (criteria) and four alternatives.

3 Model functions

Figure 1 shows the 'ModelView' window consisting of three panes that contains a completed model.

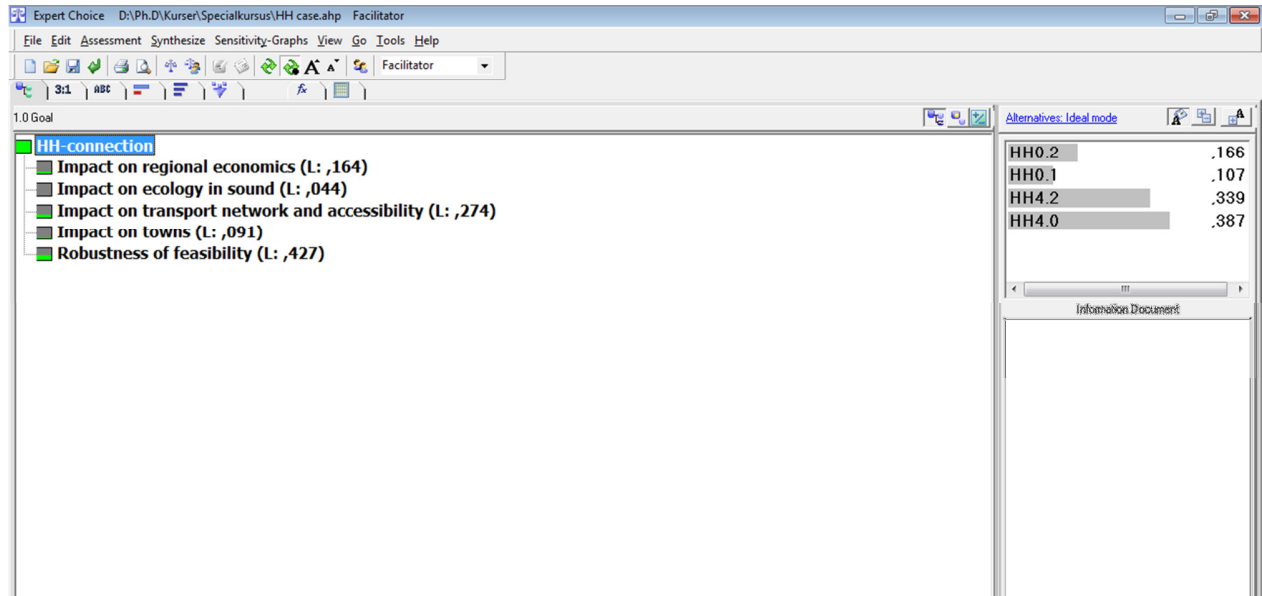


Figure 1. The model view

The 'TreeView' pane displays the hierarchical listing of the objectives and sub-objectives. This is where the objectives and sub-objectives are entered. Each element in the 'TreeView' is normally referred to as a 'Node'.

The 'Alternatives' pane displays the active alternatives. Alternatives can be added to the model from this pane or from the 'Data Grid'.

The 'Information document' pane displays information about the highlighted objective or alternative in either the 'TreeView' or 'Alternatives' pane.

3.1 Assessments / pair wise comparisons

One of the major strengths of the AHP and Expert Choice is the use of pair wise comparisons to derive ratio scale priorities, as opposed to using traditional approaches of "assigning weights" which can also be difficult to justify (Goodwin & Wright, 2009). Once the model is built, the next step is to evaluate the elements by making pair wise comparisons. A pair wise comparison is the process of comparing the relative importance, preference, or likelihood of two elements (objectives) with respect to another element (the goal) in the level above (Belton & Stewart, 2002). The user will make pair wise comparisons throughout the model to establish priorities.

There are three pair wise comparison assessment modes in Expert Choice.

3.1.1 Verbal judgments

The 'Verbal Comparisons' window is divided into two sections. Verbal judgments are made in the top pane. Two elements are compared with respect to their parent. What makes 'Verbal Comparisons' unique is that words are used to represent the magnitude of the scale. The slider bar on the right side of the pane is used to indicate which element is preferred and the strength of that preference is represented by a corresponding word. The two opposing sides of the scale represent each element being compared, see Figure 2.

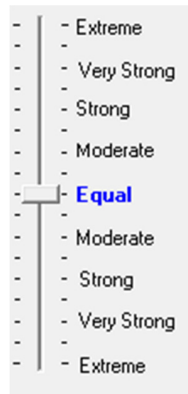


Figure 2. The verbal scale for judgments

The numerical representations of the verbal judgments are displayed in the comparison matrix as numbers from 1 to 9. If the row element (on the left) is preferred, then the judgment is displayed in black. If the column element is preferred, then the judgment is "inverted" and displayed in red. When enough judgments have been made to calculate priorities, they will also be displayed as bar graphs that overlay the row elements.

Judgments can be made any of the following ways:

- Drag the slider bar with the mouse
- Click on a statement (i.e. 'Moderate', 'Strong') next to the bar (or between two statements)

To invert a judgment (to select the other element in the comparison) the 'Invert' button can be clicked to select the other side of the comparison scale.

The judgments can also be directly entered in the comparison matrix by clicking on the cell representing the comparison you want to judge and type a number from 1 to 9; see the numerical representations of verbal judgments.

3.1.2 Numerical judgments

The 'Numerical Comparisons' window is divided into two sections. Numerical judgments are made in the top pane. Two elements are compared with respect to their parent using a numerical scale. The slider bar is used to indicate which judgment is preferred and the strength of that preference. The two opposing sides of the scale represent each element being compared.

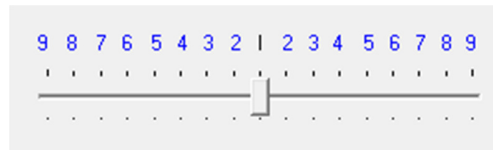


Figure 3. Numerical scale for judgments

The numerical equivalents of the judgments are displayed in the comparison matrix as numbers from 1 to 9. If the row element (on the left) is preferred, then the judgment is displayed in black. If the column element is preferred, then the judgment is "inverted" and displayed in red. When enough judgments have been made to calculate priorities, they will also be displayed as bar graphs that overlay the row elements.

Judgments can be made any of the following ways:

- Drag the slider bar with the mouse
- Click on a number above the bar

To invert a judgment (to select the other element in the comparison) the 'Invert' button can be clicked to select the other side of the comparison scale. The judgments can also be entered directly in the comparison matrix.

3.1.3 Graphical judgments

The 'Graphical Comparisons' view is divided into two sections. Graphical judgments are made in the top pane. Two elements are compared with respect to their parent with bar graphs. The lengths of the bars indicate the relative dominance of the elements. If they are of equal length, then the elements are equally important. If one bar is twice as long as the other, then it is twice as important. Relative dominance is also represented with a pie chart on the right side of the pane, see Figure 4.

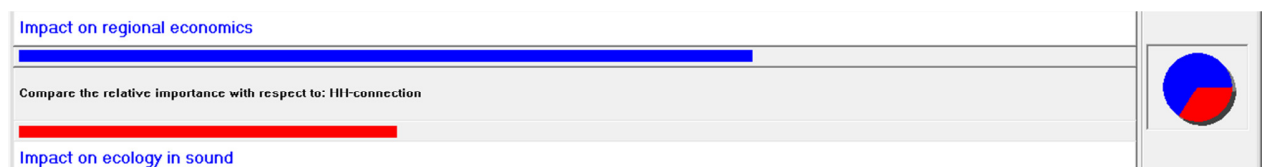


Figure 4. Graphical judgments

The numerical representations of the graphical judgments are displayed in the comparison matrix as numbers. If the row element (on the left) is preferred, then the judgment is displayed in black. If the column element is preferred, then the judgment is "inverted" and displayed in red. When enough judgments have been made to calculate priorities, they will also be displayed as bar graphs that overlay the row elements.

Judgments can be made by dragging either the blue or red bar with the mouse. To invert a judgment (to select the other bar in the comparison) the Invert button can be clicked. The judgments can also be entered directly in the model using a number from 1 to 9.

3.1.4 Inconsistency

The inconsistency measure is useful for identifying possible errors in judgments as well as actual inconsistencies in the judgments themselves; this is accessed from the 'Priorities with respect to' window. In general, the inconsistency ratio should be less than 0.1 or so to be considered reasonably consistent (Belton & Stewart, 2002). The 'Priorities with respect to' window also shows how many missing judgments are in the set of elements being compared.

After the judgments have been entered, it is possible to request suggestions for reducing the inconsistency. This can be done from any comparison mode.

- Select 'Inconsistency, 1st' from the menu to identify the most inconsistent judgment.
- Select Inconsistency, Best Fit.

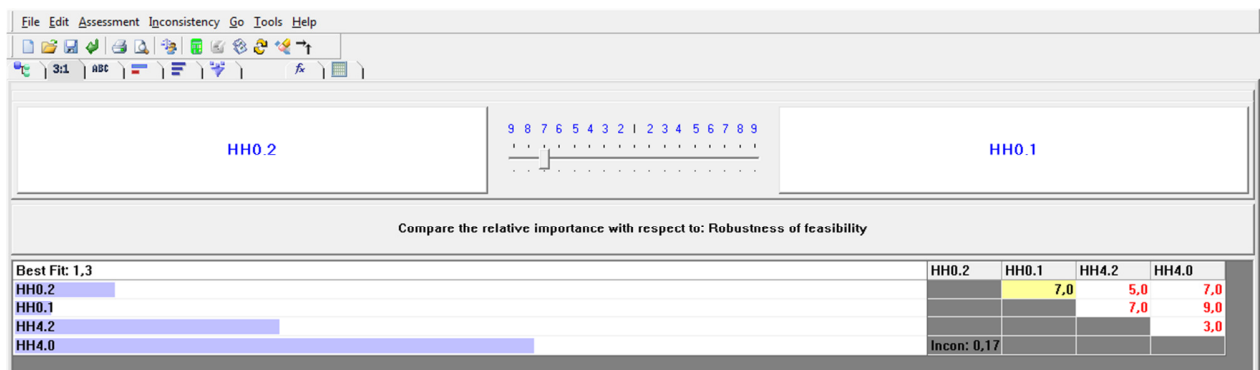


Figure 5. Inconsistency check

Figure 5 shows the 'Best Fit', where the judgment between HH0.2 and HH0.1 should be 'Equal' as indicated by the 'Best Fit' indicator of 1,3 located above the matrix. Note that a judgment of very strong (7) has been entered. It is also possible to identify the 2nd, 3rd,..., and 9th inconsistency in the matrix and find the 'Best Fit'.

3.2 Entering ratings

In the 'Data Grid' it is possible to use the 'Ratings' function which specifies intensities, see Figure 6, that can be assigned to the alternatives under the criteria.

Intensity Name	Priority
High	1
Middle	0,56
Low	,320

Figure 6. Example on specified intensities

Figure 7 depicts how the ratings intensities can be assigned to the alternatives in the 'Data Grid'.

High		Middle		Low	
1 (1,000)		2 (.560)		3 (.320)	
Ideal mode	RATINGS	PAIRWISE	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Impact on regional economics	Impact on ecology in sound	Impact on transport network and accessibility	Impact on towns	Robustness of feasibility
<input checked="" type="checkbox"/> HH0.2	Middle				
<input checked="" type="checkbox"/> HH0.1	Low				
<input checked="" type="checkbox"/> HH4.2	High				
<input checked="" type="checkbox"/> HH4.0	Middle				

Figure 7. Example on ratings

Notice that the specified intensities appear above the alternatives on the 'Data Grid'. By clicking on a ratings intensity the intensity will appear in the cell.

The 'Data Grid' also provides the opportunity for specifying a step function (see Figure 8), a utility curve (see Figure 9 and Figure 10) or direct priority (see Figure 11).

High		Middle		Low	
1,000		,540		,240	
1		2		3	
Ideal mode	RATINGS	STEP	PAIRWISE	PAIRWISE	PAIRWISE
Alternative	Impact on regional economics	Impact on ecology in sound	Impact on transport network and accessibility	Impact on towns	Robustness of feasibility
<input checked="" type="checkbox"/> HH0.2	Middle	1			
<input checked="" type="checkbox"/> HH0.1	Low	1			
<input checked="" type="checkbox"/> HH4.2	High	2			
<input checked="" type="checkbox"/> HH4.0	Middle	3			

Figure 8. Example on a step function

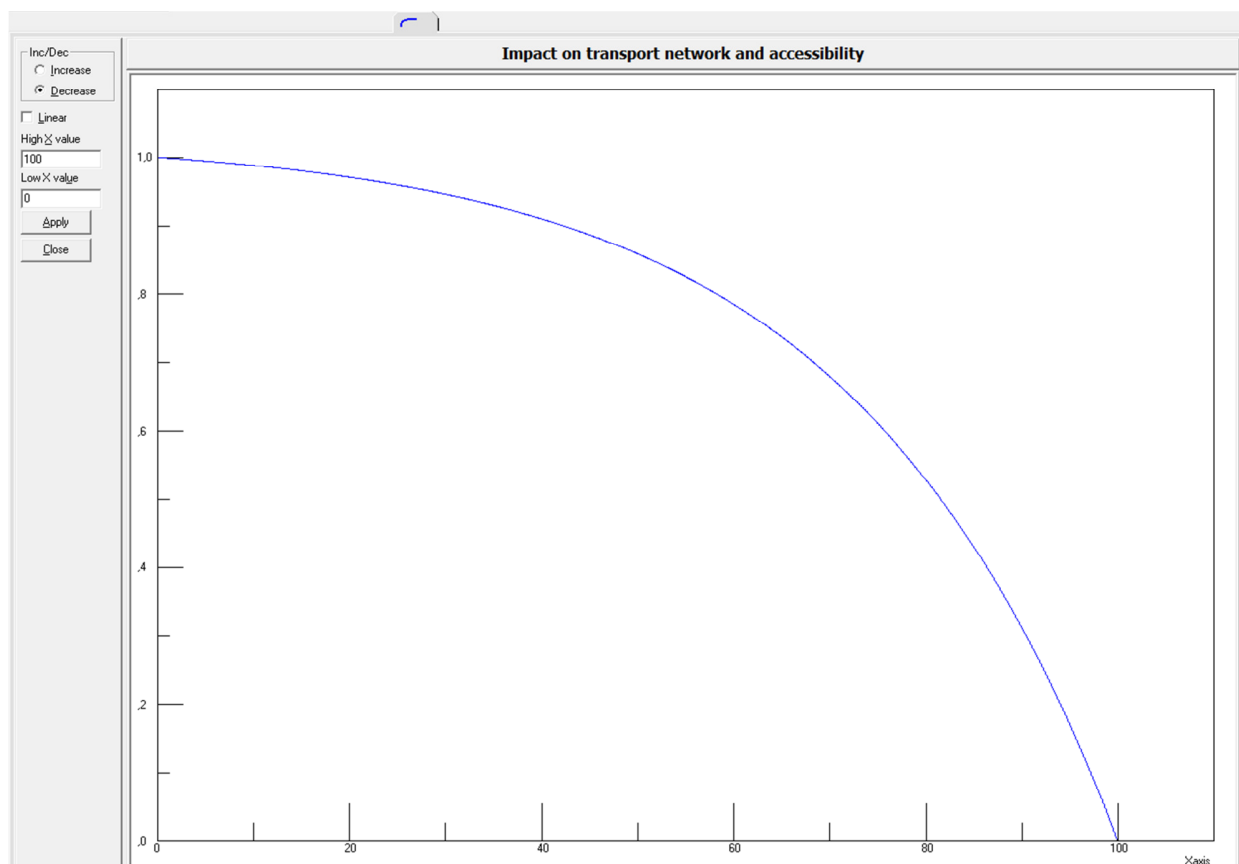


Figure 9. Example on a decreasing utility function. It is also possible to select an increasing function and specify whether the function should be linear or not.

Low		High		Curvature	
0.		100.		Concave	
Ideal mode	RATINGS	STEP	DECR	PAIRWISE	PAIRWISE
Alternative	Impact on regional economics	Impact on ecology in sound	Impact on transport network and accessibility	Impact on towns	Robustness of feasibility
<input checked="" type="checkbox"/> HH0.2	Middle	1	90		
<input checked="" type="checkbox"/> HH0.1	Low	1	100		
<input checked="" type="checkbox"/> HH4.2	High	2	0		
<input checked="" type="checkbox"/> HH4.0	Middle	3	50		

Figure 10. Example on the utility function in the 'Data Grid'.

Low		High		Curvature	
0.		100.		Concave	
Ideal mode	RATINGS	STEP	DECR	DIRECT	PAIRWISE
Alternative	Impact on regional economics	Impact on ecology in sound	Impact on transport network and accessibility	Impact on towns	Robustness of feasibility
<input checked="" type="checkbox"/> HH0.2	Middle	1	90	0.3	
<input checked="" type="checkbox"/> HH0.1	Low	1	100	1	
<input checked="" type="checkbox"/> HH4.2	High	2	0	0	
<input checked="" type="checkbox"/> HH4.0	Middle	3	50	0.1	

Figure 11. Example on direct ratings – entered without any pre-specification.

3.3 Synthesis – obtaining the results

A synthesis can be done for either the entire model or a portion of the model. From the 'ModelView', the 'Synthesize, With Respect to Goal' is selected. The synthesis window will then appear, showing the results (see Figure 12). Note the 'Ideal' and 'Distributive' buttons.

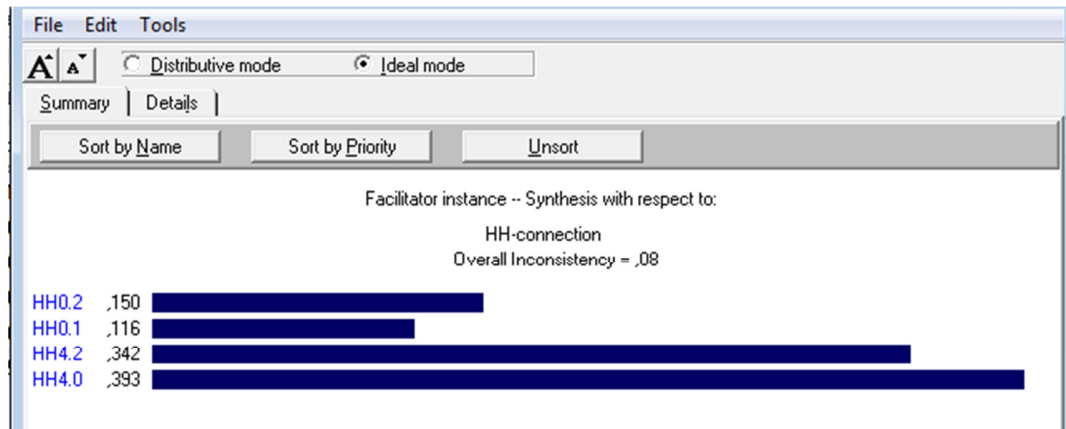


Figure 12. Results view

The 'Ideal synthesis mode' assigns the full weight of each covering objective to the best (highest priority) alternative for each covering objective. The other alternatives receive weights under each covering objective proportionate to their priority relative to the best alternative under each covering objective. The weights/priorities for all the alternatives are then normalised so they sum to 1. When using the ideal synthesis mode, the addition or removal of alternatives (that are not best on any covering objective) will not impact the relative priorities (ratios or ranks) of other alternatives. The ideal mode should be used when selecting one alternative from many and when the priorities of the alternatives not selected are not of interest (Expert Choice, 2004).

The 'Distributive mode' distributes the weight of each covering objective to the alternatives in direct proportion to the alternative priorities under each covering objective. When using the distributive synthesis mode, the addition or removal of an alternative results in a re-adjustment of the priorities of the other alternatives such that their ratios and ranks can change. The distributive mode should be used when measuring under conditions of scarcity – for example when forecasting outcomes whose probabilities must add to 1, or when looking at elections where votes cast for one candidate may alter the rank of another candidate. Because each synthesis mode combines priorities differently, it can be noticed that each mode may yield different, although normally very similar, results (Ibid.).

3.4 Sensitivity analyses – graphs

Sensitivity analyses from the 'Goal' node will show the sensitivity of the alternatives with respect to all the objectives below the goal. It can also be performed from the nodes under the goal if the model has more than three levels to show the sensitivity of the alternatives with respect to an objective or sub-objective.

When performing a sensitivity analysis it is possible to vary the priorities of the objectives and observe how the priorities of the alternatives would change. There are five types of sensitivity analysis embedded within Expert Choice.

- Dynamic
- Performance
- Gradient
- Head to head
- Two-dimensional (2D plot)

The different types of sensitivity analyses can be opened at once or each one separately. Each graph has its own unique menu commands and each sensitivity analysis can be compared to a "what-if" analysis because the results are temporary.

3.4.1 Dynamic sensitivity

'Dynamic Sensitivity' analysis is used to dynamically change the priorities of the objectives to determine how these changes affect the priorities of the alternative choices. By dragging the objective's priorities back and forth in the left column, the priorities of the alternatives will change in the right column. If a decision-maker thinks an objective might be more or less important than originally indicated, the decision-maker can drag that objective's bar to the right or left to increase or decrease the objective's priority and see the impact on the alternatives. Figure 13 shows a Dynamic sensitivity graph.

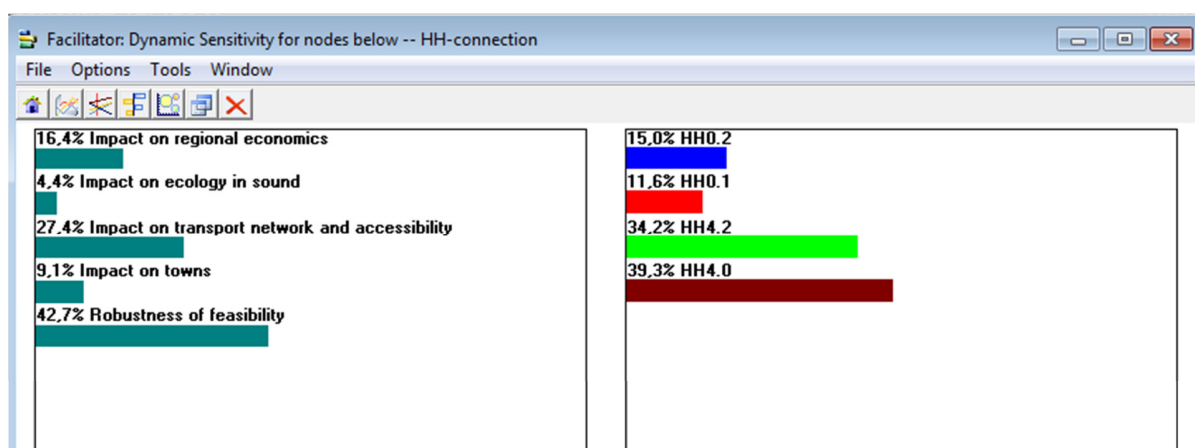


Figure 13. Dynamic sensitivity graph

3.4.2 Performance sensitivity

The 'performance sensitivity' analysis, displayed in Figure 14, shows how the alternatives were prioritised relative to other alternatives with respect to each objective as well as overall.

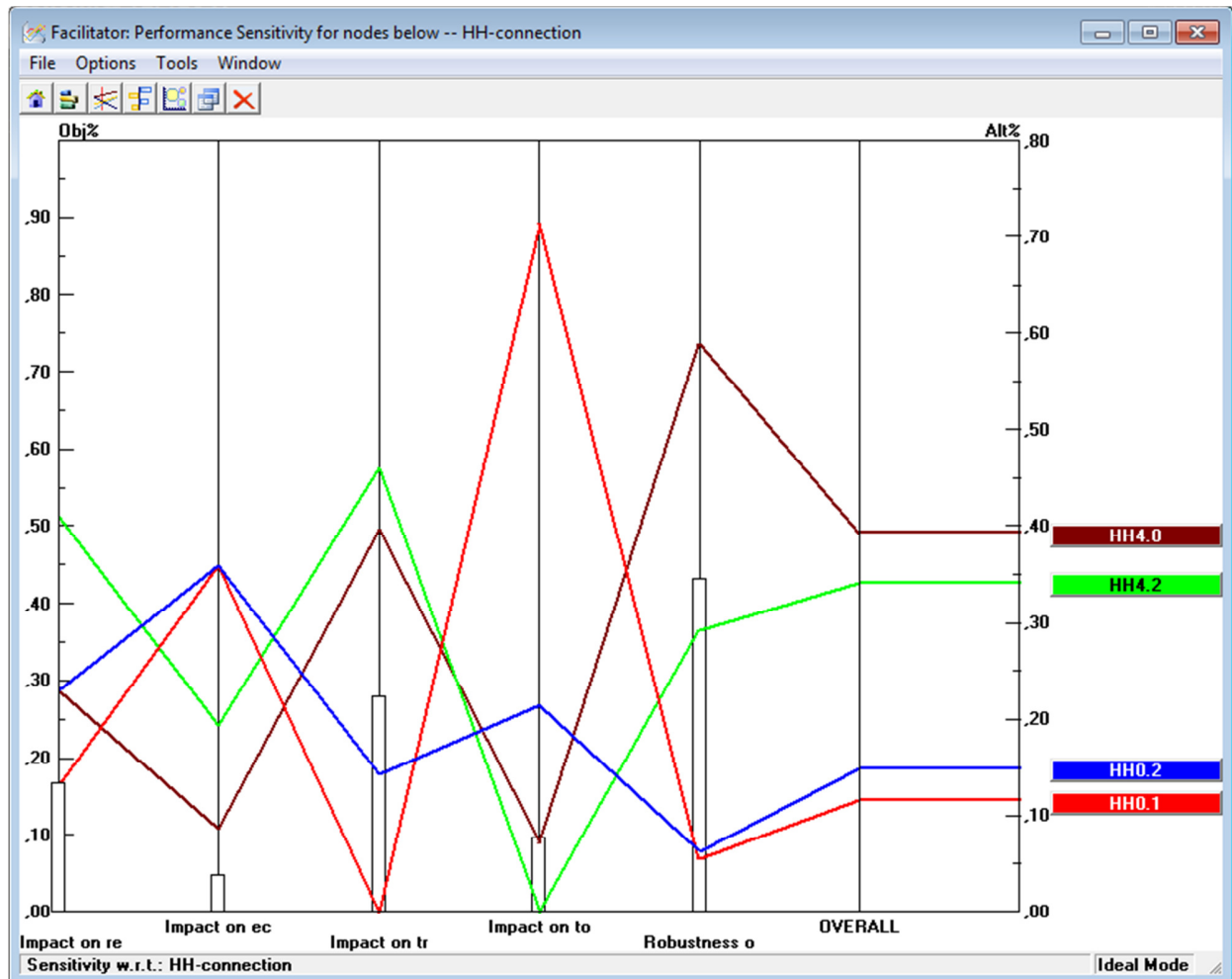


Figure 14. Performance sensitivity graph

To see how the best alternative performs compared to the second, third and fourth alternatives, read the overall priority from the intersection of the right y-axis and the overall priority for each alternative. In the case example, HH4.0 is approximately 0.39, HH4.2 is approximately 0.34 and so on. Note that the priorities for the alternatives sum to one.

To read each objective's priority (based on the decision-makers' pair wise comparisons), the left y-axis should be used. For example 'Robustness' is about 0.43 while 'Impact on towns' is about 0.09 and so on.

To read the alternative priorities with respect to each objective, read from the right y-axis. In the case example, using 'Robustness', HH4.0 has a priority of approximately 0.59, while HH4.2 is about 0.30 and so on. The graph is also dynamic, so the relationship between the alternatives and their objectives can temporally be altered by dragging any one of the objective bars up or down.

3.4.3 Gradient sensitivity graph

The 'gradient sensitivity' graph shows the alternatives' priorities with respect to one objective at a time. By choosing the menu command 'X Axis', the user has the ability to select which objective appears on the x-axis. The red vertical line indicates the objective's priority (based on the decision-maker's pair wise comparisons). To indicate where an objective's priority changes the red bar can be dragged to either the left or right; this is shown as a blue dashed vertical line.

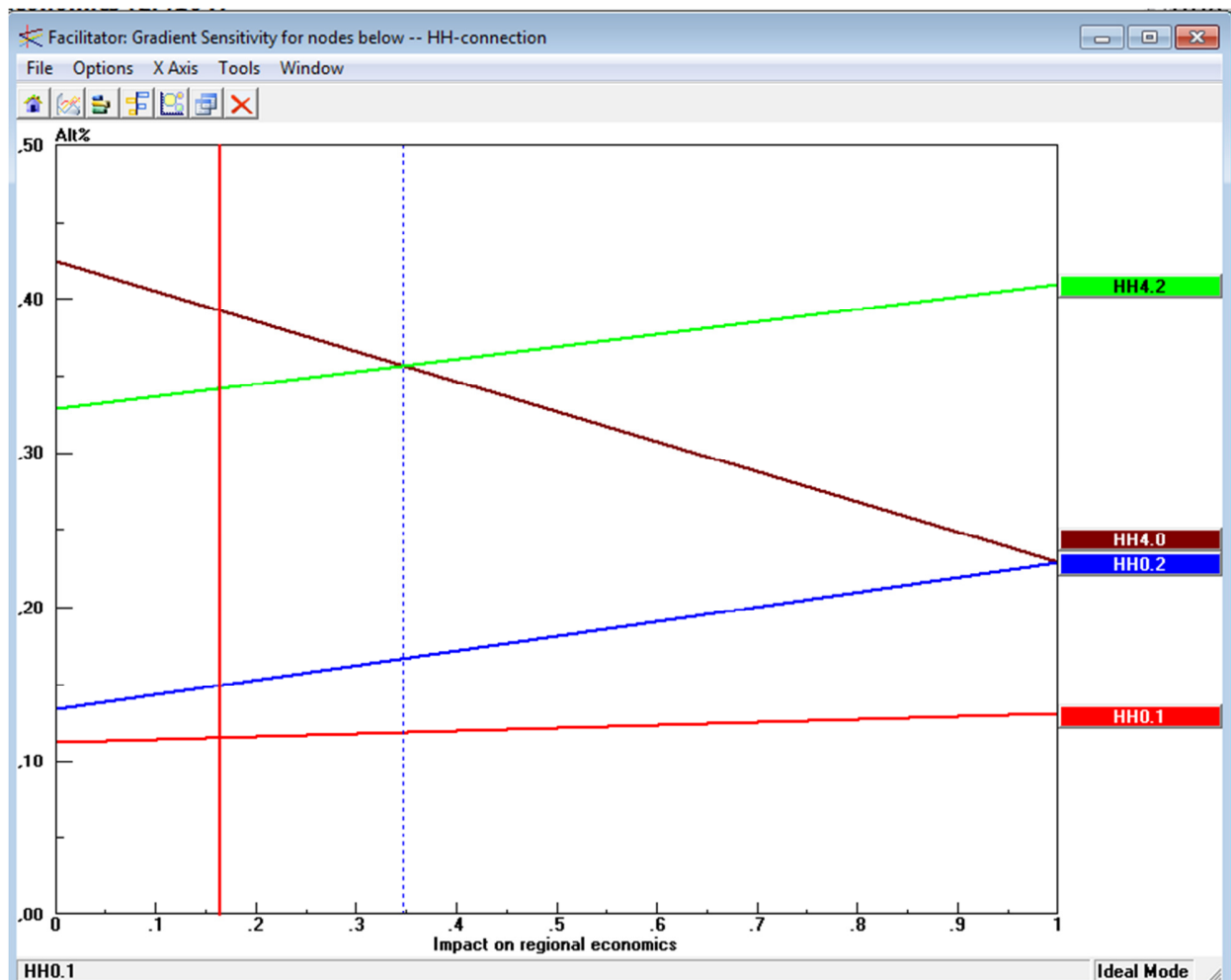


Figure 15. Gradient sensitivity graph

In Figure 15 it can be seen that increasing the priority of 'Impact on regional economics' from 0.17 to 0.35 changes the choice of the alternative with respect to 'Impact on regional economics'. When viewing a gradient graph the user should look for cross-over points of the alternatives.

3.4.4 Head-to-head graph

Figure 16 shows how two alternatives compared to one another against the objectives in a decision. One alternative is listed on the left side of the graph and the other is listed on the right. The alternative on the left is fixed while the alternative on the right can be varied, by selecting a different tab on the graph. Down the middle of the graph are listed the objectives in the decision. If the left-hand alternative is preferred to the right-hand alternative with respect to an objective, a horizontal bar is displayed towards the left. If the right-hand alternative is better, the horizontal bar will be on the right. If the two choices are equal, no bar is displayed. The overall result is displayed at the bottom of the graph and shows the overall percentage by which one alternative is better than the other; this is the composite difference. The overall priority can either be shown based on the objective weights (typical) or un-weighted.

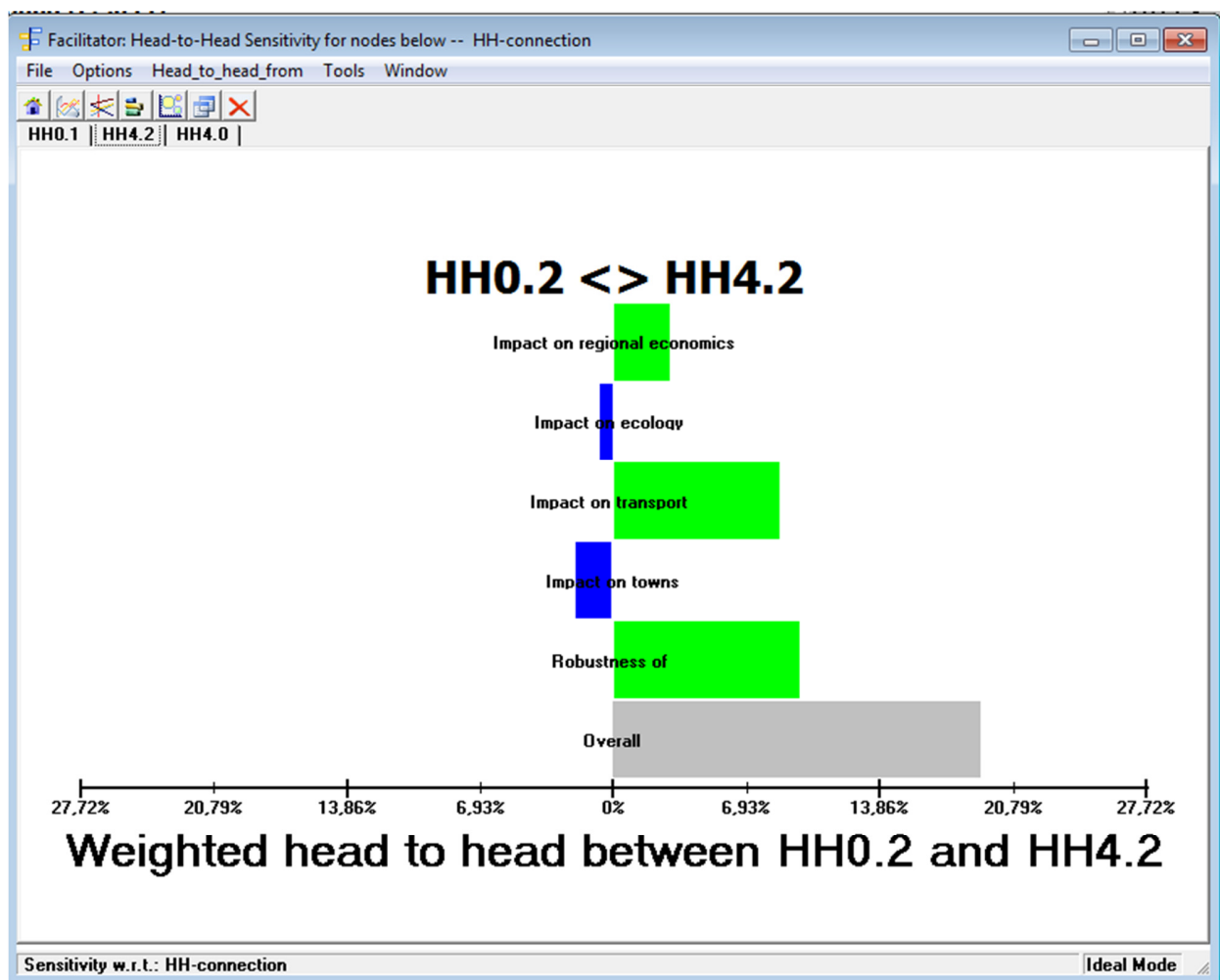


Figure 16. Head-to-head graph

3.4.5 Two-dimensional graph

The graph in Figure 17 shows the alternatives' priorities with respect to two objectives at a time. By clicking the menu commands "X Axis" and "Y Axis" you have the ability to change the objectives being displayed.

The area of the 2D plot is divided into quadrants. The most favorable alternatives with respect to the objectives on the two axes will be shown in the upper right quadrant (the closer to the upper right corner, the better the alternative). The least favorable alternatives will be shown in the lower left quadrant (the closer to the lower left corner, the less favorable the alternative). Alternatives located in the upper left and lower right quadrants indicate key tradeoffs where there is conflict between the two selected objectives.

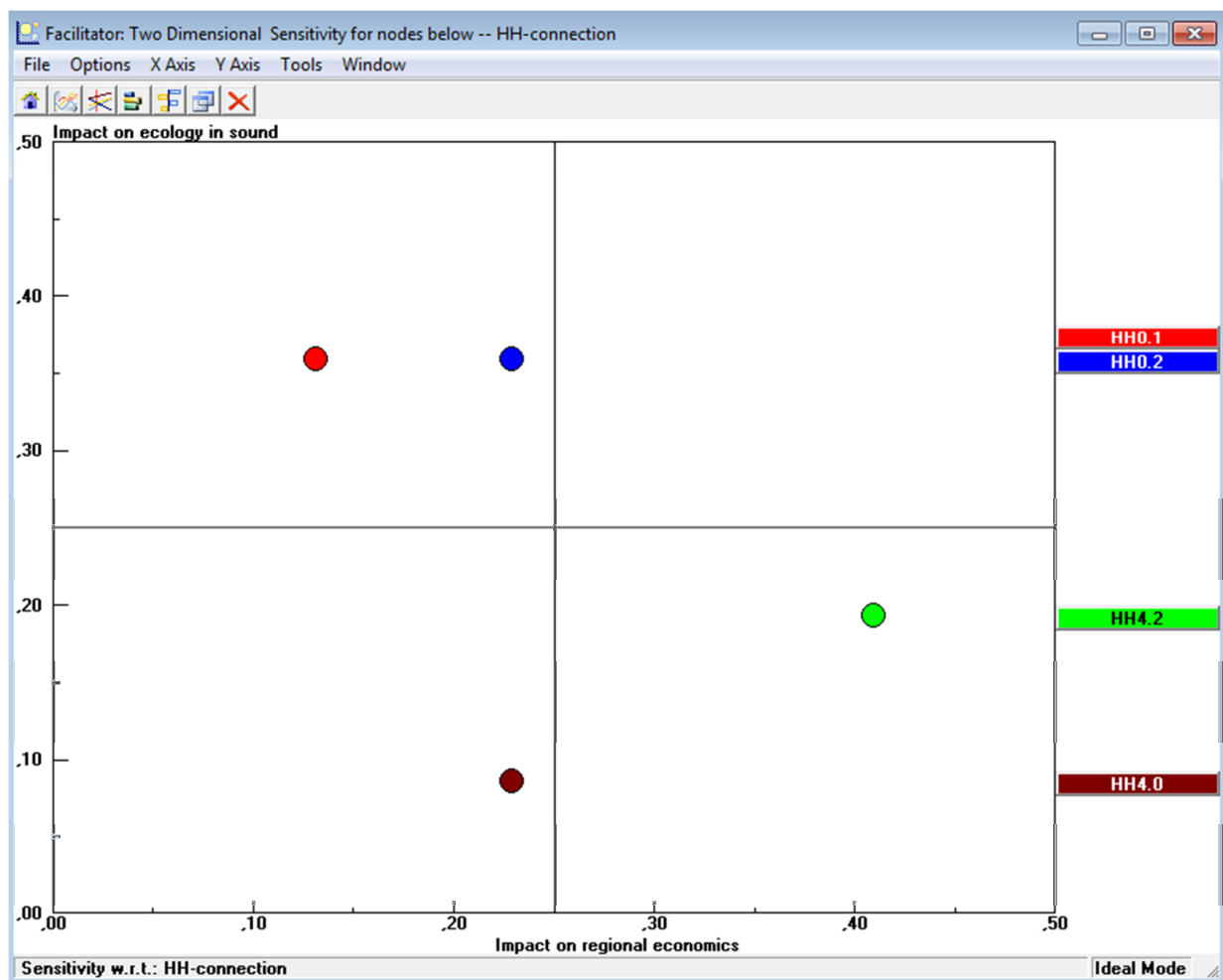


Figure 17. Two-dimensional graph

4 Group decisions

Expert Choice can be used by a team to enhance the quality of group decisions by bringing structure to the decision making process and by synthesizing different points of view. This section deals with Expert Choice's group features that help synthesize individual judgments to arrive at a group conclusion.

First, it is examined how to create a group enabled model. Second, how the group enabled models can be used, and third, how to combine participants' judgments to reach a group conclusion.

The section will be dealing with the terms of a "Facilitator" and "Participants". The facilitator builds the Expert Choice model and facilitates the group decision-making process or session (sometimes in practice, one person (a decision analyst) may build the model and another person might facilitate the group session). Individual members of the group or team who evaluate the model will be referred to as participants.

Prior to the group session (or what can be referred to as a decision conference), the facilitator, and perhaps the problem owner, might meet to build the model and enter participants' names, demographics, passwords and other information as applicable. Alternatively, the facilitator and the group might build the model during a group session.

The facilitator or decision analyst will present the group enabled model and explain what is in the 'Model View' and 'Data Grid'. Then he or she will explain what portions of the model the group are going to evaluate. Next the facilitator can turn on the receiver and keypads. If keypad hardware is not available, the facilitator can solicit votes orally and use the computer keyboard to enter participants' votes one at a time.

Other functions of the facilitator include calculating a set of group judgments; combining all participants' judgments and data to obtain a group result as well as displaying a synthesis; and performing sensitivity analyses.

It can also be noted that Expert Choice's 'Decision Portal' enables members of a group to enter judgments about a decision model in a browser over the Internet. This is, however, not examined further in this report. It is possible to make group decisions using a network as well. All participants are provided with a copy of the model which they then can evaluate using a personal ID certificate. After completion of the assessments the model is returned to the facilitator who combines the participant's contributions.

4.1 Facilitator vs. participant functions

What the facilitator can do:

1. Only the facilitator can create/modify a model's structure and enter/edit 'Information documents'.
2. 'Structuring', a model building technique, is available to the facilitator. It is an especially effective tool when all the members of a group are in the same place and can jointly structure a model with the aid of a facilitator.
3. From the 'participant table', the facilitator enters participants and demographic information about each participant.
4. The facilitator defines 'Data Grid' formula types; sometimes with the group's assistance.
5. The 'Edit, Revert' command, useful to revert to prior model states during a session, is available only for the facilitator.
6. The facilitator will lead the group when making pair wise comparisons with respect to the objectives/criteria and alternatives.
7. The facilitator can also enter his/hers personal judgments and/or data to be combined with other participants' judgments and data. This is, however, not recommended as the facilitator should be impartial (Phillips, 2007).
8. The facilitator will combine judgments of some or all of the participants and show the results to the group.
9. The facilitator will show the group sensitivity analyses and discuss with the group if model iteration is needed.
10. If iteration is needed the facilitator and the group will decide what portions of the model will be reviewed and revised.

What the participants can do:

1. Participants can make judgments about the various aspects of the decision problem including:
 - a. making pair wise comparisons
 - b. entering ratings or data in the 'Data Grid', and
 - c. creating notes explaining their judgments as well as other issues or concerns, if on a network.
2. Participants can undo judgments or undo editing where appropriate.

3. Participants can review their own decision model, perform a synthesis, display sensitivity graphs as well as review the contents of the 'Data Grid'.
4. If permitted by the facilitator, participants can view and print one or more of the combined results and review the group sensitivity analyses.

4.2 Creating a group model

Expert Choice can be used to create and evaluate a team model either on a local area network, the Internet, or with an audio response system using radio frequency keypads. To create a group model, the facilitator (or the decision analyst) first builds a decision model, and then add participants as described below. Figure 18 depicts the decision hierarchy when entered in Expert Choice.

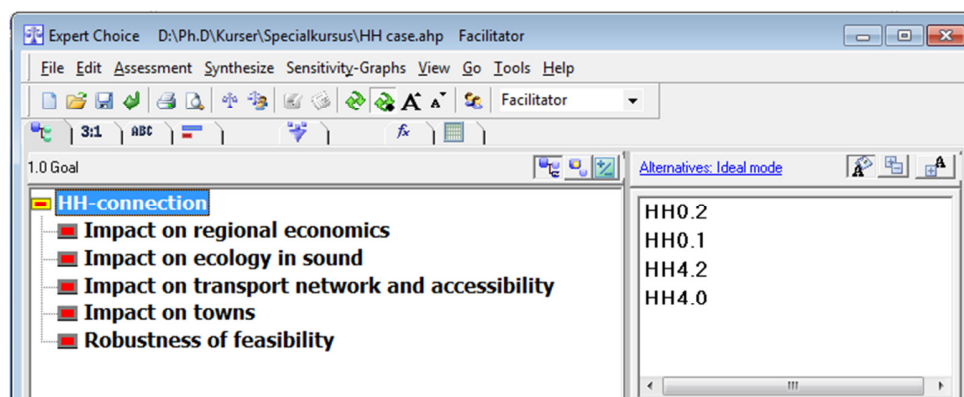


Figure 18. Decision hierarchy for the HH case study

The first step will following be to add participants to and group enabling the model. In this respect it should be noted that one must be logged on as the facilitator to group enable and add participants to the model (this function is controlled by the current license of the institute).

In order to group enable the model the 'Participants Table' is selected in the 'Go' menu. By selecting 'Edit' and following 'Group enable' a 'Combined' instance is added into the table. This is the instance that will hold the group's results. In order to add participants to the model 'Edit' is selected and then 'Add N Participants'. For the case considered the number of participants is set to 4, see Figure 19.

PID	PersonName	Combined	Email	Participating	Eval	Location	Weight	Keypad	Wave	Password	ProgressStatus	EvalCluster	Organization	LastChanged
0	Facilitator	<input type="checkbox"/>		<input type="checkbox"/>										04-08-2011 09:11:38
1	Combined	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>										04-08-2011 09:01:13
2	P2	<input type="checkbox"/>		<input checked="" type="checkbox"/>				2	1					
3	P3	<input type="checkbox"/>		<input checked="" type="checkbox"/>				3	1					
4	P4	<input type="checkbox"/>		<input checked="" type="checkbox"/>				4	1					
5	P5	<input type="checkbox"/>		<input checked="" type="checkbox"/>				5	1					

Figure 19. Participants table

If desired it is possible to add names and contact information to the participants in the window. Moreover, it is possible to specify if one or some of the participants' assessments should be regarded more or less important than others. This is set in the 'Weight' column. If nothing is specified here all participants are regarded to be equal and the combined assessments are calculated by geometric mean values of the individual assessments made.

Demographic information such as organization, password and keypad number can also be entered as desired. If a password is entered, it will be encrypted. It should also be noted that fields can be added to the participants table for department, age and gender.

If the participants are not in the same room when the assessments are made, e.g. if the assessment process is conducted web-based or if different persons are doing assessments of different parts (clusters) of the issue, it can be attractive to enter the participants locations and what clusters they are assessing. This will mostly be necessary in cases where large and very complex decision problems are to be assessed.

For an ordinary decision conference with a limited number of participants all present in the same room the participants table could look as depicted in Figure 20.

PID	PersonName	Combined	Email	Participating	Eval	Location	Weight	Keypad	Wave	Password	ProgressStatus	EvalCluster	Organization	LastChanged
0	Facilitator	<input type="checkbox"/>	mbb	<input type="checkbox"/>		115/007							DTU	04-08-2011 09:11:38
1	Combined	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>									DTU	04-08-2011 09:01:13
2	Steen	<input type="checkbox"/>	sl	<input checked="" type="checkbox"/>		115/007		2	1				DTU	
3	Anders	<input type="checkbox"/>	avj	<input checked="" type="checkbox"/>		115/007		3	1				DTU	
4	Kim	<input type="checkbox"/>	kbs	<input checked="" type="checkbox"/>		115/007		4	1				DTU	
5	Inga	<input type="checkbox"/>	inam	<input checked="" type="checkbox"/>		115/007		5	1				DTU	

Select * from People order by PID

Queries:

Figure 20. Participants table for the case study featuring a fictive decision conference

If desired, judgments and/or data can be copied from the facilitator or another participant's instance of the model when adding new participants. This is done from the participants table by using the 'Edit', 'Copy to N New Participants' command. Participants will be added just as with the 'Add N Participants' command, but in addition, the judgments and/or data from the participant row currently selected will be copied to the new participants. Deleting a participant deletes everything about that participant from the model; this includes all judgments, associated priorities and data related to that participant.

Individual judgments can be entered into a group model in one of two ways:

1. From the 'ModelView' individual participants can make judgments with respect to the objectives, sub-objectives and alternatives. This is done using the 'Assessment Pairwise Individuals' command.
2. From the 'Data Grid' individual participants can enter data or ratings for the alternatives with respect to covering objectives. This is done using the 'Assessment Individuals' command.

4.3 Group comparisons

In the decision situation all assessments made by the participants are gathered in the 'Pairwise Individuals' window, see Figure 21 and Figure 22.

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Facilitator																	
Steen																	
Anders																	
Kim																	
Inga																	

- HH-connection
- Impact on regional economics
- Impact on ecology in sound
- Impact on transport network and accessibility
- Impact on towns
- Robustness of feasibility

Figure 21. Window making it possible to enter all participants' assessments.

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Facilitator																	
Steen																	
Anders																	
Kim																	
Inga																	

- HH-connection
- Impact on regional economics
- Impact on ecology in sound
- Impact on transport network and accessibility
- Impact on towns
- Robustness of feasibility

Figure 22. Comparisons of two alternatives under a criterion

The model calculates the geometric average and the geometric variance of the assessments in the left corner of the window, see Figure 22. It can be noted that it is also possible for the facilitator to enter his personal assessment. The facilitator should, however, be impartial and his assessments for this reason not recorded.

4.4 Web models

Expert Choice's web models allow members of a group in e.g. various parts of the world to simultaneously open the same model over the Internet to solve problems and make decisions. In overview the process is described the following steps:

1. The facilitator creates a group model either on the destination Web server, or on a client computer. If the model is created on the client's computer it must be uploaded to the server.
2. To access the model on the server, the facilitator must create an ODBC System Data Source Name (DSN), see Expert Choice (2004).
3. The facilitator, using Expert Choice on his/her machine, can access the model via a web connection and can add to or revise the model structure. This must be done when no participants are accessing the model.
4. Participants using Expert Choice on their computers can access the model via a web connection to make judgments, enter data, and examine their results.
5. The facilitator combines the groups' judgments and or data (for all or active participants) and makes the results available to the participants

5 Discussion

This report has presented the Expert Choice DSS for MCDA. The focus has been on exposing the potential of the DSS as a tool for complex assessment problems involving groups, which has been assisted by illuminating it with a case example. The following characteristics of the DSS can be noted. Expert Choice (and thereby AHP) is simple in its design and application compared to many other MCDA techniques, as the methodology is based on simple pair wise comparisons. Furthermore, it contains qualities that make it suitable for handling complex assessment problems by incorporation of relevant MCDA-criteria and applications based on weights.

The AHP and Expert Choice software engage decision-makers in structuring a decision into smaller parts, proceeding from the goal to objectives to sub-objectives down to the alternative courses of action. Decision-makers then make simple pair wise comparison judgments throughout the hierarchy to arrive at overall priorities for the alternatives. The decision problem may involve social, political, technical, and economic factors.

The AHP helps people cope with the intuitive, the rational and the irrational, and with risk and uncertainty in complex settings. It can be used to: predict likely outcomes, plan projected and desired futures, facilitate group decision making, exercise control over changes in the decision making system, allocate resources, select alternatives, do cost/benefit comparisons, evaluate employees and allocate wage increases.

Expert Choice is in this respect intuitive, graphically based and structured in a user-friendly fashion in order to be valuable for conceptual and analytical thinkers, novices and experts. Because the objectives are presented in a hierarchical structure, decision-makers are able to “drill down” to their level of expertise, and apply judgments to the objectives deemed important to achieving their goals. At the end of the process, decision-makers are fully confident with how and why the decision was made, with results that are meaningful, easy to communicate, and actionable.

Overall, it can be concluded that Expert Choice contributes to make decisions more informed. It is moreover seen as a major feature of the approach that the various inputs needed from the decision-makers can help trigger important discussions. This issue has not been discussed thoroughly in this compendium, but the outlined approach (that can be referred to as a decision conference) is a method to support and facilitate these discussions amongst decision-makers. A future research task of the Expert Choice DSS could thus be to explore the modelling and decision-maker interaction further with the purpose of improving the learning and understanding among the decision-makers about the appraisal task.

References

- Belton, V., & Stewart, T.J. (2002). *Multi Criteria Decision Analysis – An Integrated Approach*. Kluwer Academic Publishers.
- Expert Choice (2004). Expert Choice 11 – quick start guide and tutorials. Arlington, United States of America.
- Goodwin, P., & Wright, G. (2009). *Decision Analysis for Management Judgment*. (4th ed.). Wiley.
- Larsen, L.A. and Skovgaard, B.Z. (2010). Appraisal of alternatives concerning a fixed link between Elsinore and Helsingborg. Master thesis, Technical University of Denmark, January 2010 (in Danish).
- Phillips, L.D. (2007). Decision conferencing. In W. Edwards, R.F. Miles, & D. von Winterfeldt (Eds.), *Advances in Decision Analysis* (pp. 375-399). Cambridge University Press.
- Saaty, T. L. (1977). Scenarios and priorities in transport planning: Application to the Sudan. *Transport Research*, 11, 343-350.