IMPERIA Project Report

Comparison of Multi-Criteria Decision Analytical Software

Searching for ideas for developing a new EIA-specific multi-criteria software

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1. Introduction

Multi-Criteria Decision Analysis (MCDA) is a general term for systematic approaches that can be used to support the analysis of multiple alternatives in complex problems involving multiple criteria. In practice, the problem is typically constructed into a tree-like hierarchy of criteria and alternatives. The alternatives are evaluated with respect to each criterion, and the criteria are weighted according to the stakeholders' or decision makers' assessment of their importance. As a result, one gets overall values of alternatives that reflect the preferences of the decision maker as well as the performance of the alternatives with respect to each criterion. A single decision maker can use the approach to support his/her personal decision making, whereas in group collaboration, the approach can be applied to support the participation and systematic evaluation and synthesis of different views of the stakeholders. The application areas of MCDA include, for example, environmental planning, particularly in public decision making, where the need for this kind of systematic and transparent evaluation of alternatives from different perspectives is needed to make justified and well-grounded decisions.

Various multi-criteria software or decision support systems (DSS) have been developed to support the use of MCDA methods in practice. Besides computational support for implementing the methods and the calculation of the results, the software usually provide various ways to also support other phases of the process, such as construction of the model and analysis of the results. Especially, the graphical user interfaces of the systems can provide various possibilities to visualise the process and the results, and consequently make the understanding of the results more transparent.

In this study, we report the results of the comparison of various MCDA software in terms of the features they provide. The study is a part of the IMPERIA (Improving environmental assessment by adopting good practices and tools of multi-criteria decision analysis) project, where one objective is to develop the MCDA practices and software for the purposes of supporting the environmental impact assessment (EIA) process. We analyze the existing software with an aim to find out good practices and innovative implementation solutions applied in the software that can also be utilized in our development work. More specifically, our objectives include

- to survey what kind of software there are available and compare the features they provide
- to identify good practices on how the software can be applied to provide support for carrying out the process
- to identify good practices on how to visualize the results of MCDA
- to find out useful or innovative features of the software from the viewpoint of MCDA supported EIA process that can be utilized in our work

In our development work, the aimed user group of our software is the EIA practitioners and authorities carrying out the EIA process. Although being experts in EIA, usually these people are, however, not very familiar with the MCDA methodology. Thus, one requirement of the software is that also these people would be able to use the software, which consequently sets requirements for the applied methods and how they are implemented in the software. In this respect, we think that besides analyzing general-purpose MCDA software, it would also be useful to analyze some application-specific software to get some ideas of how MCDA can be applied in certain quite a specific cases.

Although the focus of the IMPERIA project is in the EIA process, this analysis is conducted on such a general level that its results are expected to also be useful for other purposes. Of the above list of objectives, only the last one is specifically related to the IMPERIA project, but the other objectives are very general. Thus, the results of this study can also be utilized, for example, in finding software for various purposes with certain needs and requirements.

This study is constructed as follows. First, we describe the evaluation framework that was used to compare the software. Next, we present the results of our study and discuss the general trends as well as the innovative features used in the software. Then, we analyze the software from the viewpoint EIA specific MCDA software development and discuss what features or implementation practices can be utilized in the development work carried out in the IMPERIA project. Finally, the concluding remarks are given.

2. Evaluation framework

We compared the software with a framework, in which each software is evaluated in terms of fulfilling a list of various needs on different phases of the process. The obtained comparison table is complemented with written comments including special features of the software for each phase of the process as well as general comments. The evaluation framework and the results of the survey are presented in Appendix A.

2.1 Criteria for the evaluation

The criteria in the comparison tables are divided into categories based on the main phases of the decision analysis process (model construction, criteria weighting, analysis of the results). On each category, we have recorded the support provided by the software for the different tasks and/or methods of this phase. For example, on criteria weighting, we have listed which MCDA methods are supported by the software. The aim is to get an overview of the provided support and of how well the different phases are supported by the software. On each phase, we have also specified the feature list with written comments on, for example, whether there are some innovative features or good practices that can be found in the software to support this particular phase.

In addition to the phase-wise support, we have collected experiences on whether and what kind of process support the software provides. In practice, the use MCDA methods requires certain expertise from the person carrying out the process, as there are, for example, various biases that can happen with an improper use of the methods. Typically, the MCDA software are designed to be used by the experienced decision analysts, and the responsibility of the proper use of the methods is left to the user. However, in the IMPERIA project, the aim is to develop a software that can also be used by 'semi-experts' (i.e. EIA practitioners that are not that familiar with the MCDA methods), as we believe that with proper process support and guidance to the methods, the possibility of the biased used of the methods can be diminished. Thus, we have also evaluated this in our study, with an aim to find out the innovative practices of the software also in this respect.

Typically, the MCDA analysis is carried out on a single decision maker or stakeholders at a time, as each person has his/her own preferences over the criteria. In a case of several stakeholders, the group can estimate common preferences representing some average or typical opinion of the whole group. However, often it is more fruitful to allow each group member to give his/her own preferences to see the variety of the different opinions. Some software also provide explicit group support in either of these forms, and we have also documented what kind of group support there is available in the software.

In addition to these issues, we have documented some general features of the software, such as compatibility with Excel and whether the software are generic or specifically designed for some application or application area. We have also documented the most characteristic features of the software. The aim of our IMPERIA project is to develop good practices for the EIA process, and thus, we have also documented the features that can be considered especially useful in terms of supporting the EIA process. In this respect, especially the application-specific software is of our interest, as they often might give ideas about supporting certain cases that can be quite specifically defined.

2.2 Selection of the software

There are numerous different MCDA software available on the Internet to be used on-line or to be downloaded. Our aim was not to analyze every single software, but to mainly focus on those software that has been actively used or that have achieved some status among the practitioners and MCDA community (which can be seen as one indication of the software offering such features that make it worth using). Our main sources for searching the software to be analyzed were review or comparison articles of the software

in international academic publications (French and Xu, 2005; Vassilev et al., 2005; Weistroffer et al., 2005) and link lists on web pages related to MCDA software (EWG-MCDA, OR/MS Today, Wikipedia). In addition, we did a web search with various combinations of keywords “MCDA”, “MAVT”, “multi-criteria”, “multi-attribute”, “software”, “decision support”.

We have only studied such software that can be classified under the term *multiple attribute decision making* in the classification of Weistroffer et al. (2005). Thus, software for *multiple objective decision making*, *sorting problems* and *portfolio analysis* are omitted from this study. Some software also provide *group decision support* along with the multi-attribute support, but we have not explicitly studied such group support software that do not provide MCDA features. Furthermore, we mainly analyzed general-purpose software, but the analysis also included a few *application-specific software* tailored for some certain application. Often these tailored software are, however, so specific that they cannot be directly adapted into other application areas. Nevertheless, with respect to identifying good practices for tailoring MCDA methods for certain purposes, we saw it useful to also analyze some of these.

Some software in our analysis are not actually single software, but more like resource collections. *Decision Deck* is an open source software collection that currently includes a few freeware decision support modules. *MCDA-res* is a resource collection providing guidelines for carrying out MCDA process in renewable energy resource (RES) cases. However, the projects themselves were quite interesting in terms of having similar as our IMPERIA project and thus, they were also included into our analysis.

With the search using the above-mentioned preconditions, we were able to identify tens of different software. However, we did not saw it necessary to include all these into our comparison, but rather a variety of different software with different purposes. Thus, we selected 24 software or resource collections to our final survey, mainly based on the availability of some demo or trial version of the software. We are aware that, consequently, some popular or well-known software might have been eliminated from our survey, but we do not consider this as a big flaw, as an adequate spectrum of different approaches is expected to be obtained already with this number.

3. Results of the comparison

Next, we analyse the results of our comparison. The full comparison tables of the software in terms of different features are available in Appendix A, and the table numbers in the following discussion refer to these. The links to the web pages of the software are presented in Table 9. Some screenshots of the software are presented in Appendix B to get an overview of their design.

3.1 Developer and purpose of the software (Tables 1, 7 and 8)

Approximately half of the software in our survey have been developed by academic actors (such as universities or institutes), and the rest by commercial actors. On the academic software, the developers typically provide the software for free, but with a restriction to academic or non-profit purposes only. However, the classification between academic and non-academic software is often ambiguous, as many academic software developers have commercial vendors that also sell commercial versions of the software. In addition, the development of many commercial software has also initially started from academic research, but after developing a fully functional product, the developers have converted it into a commercial product. Many well-known names from the MCDA community can indeed be identified also behind commercial software.

Most of the software in our survey are general-purpose software for supporting MCDA methods in general, but we have also analysed five application-specific software. Three of these are designed for forest planning, and one for both indoor air quality and renewable energy resources.

3.2 Process support (Table 2)

The use of MCDA typically requires some expertise and the level of process support provided by the software often implicitly defines the expertise required by the user. On one hand, the aim of general-purpose software is to provide decision support for as many kinds of applications as possible. Thus, to meet the needs of various applications, the software has to be flexible and provide the user a possibility to use such methods and carry out such analyses that best suit for his/her purposes. On the other hand, this flexibility also entails the responsibility to use the methods properly, as the more flexible to software is the more possibilities there are to use it incorrectly. Especially, in weight elicitation, there can exist various biases that can make the user to input such preference judgments into the model that do not represent his/her true opinions. With suitable support provided for carrying out the process, the biases are expected to be reduced, but it is still a challenge to provide such process support that simultaneously allows some flexibility in the use of the software.

One way to provide process support on general-purpose software is to just provide guidance on how to carry out the MCDA process. Almost all the software in our comparison have some kind of help pages providing overview of the process, but the responsibility to follow and understand this guidance is still left to the user. In this respect, one approach towards more profound process guidance support is to provide on-line guidance during the process so that on each task, appropriate guidance is brought to the user automatically. An example of this kind of guidance is *V.I.S.A Decisions*, which provides a decision wizard that tells the user what to do on each phase and after this guides the user to the next phase.

Another way towards more structured process support is to have a tab panel for each phase of the process. Tab panels clearly differentiate each phase of the process and suggest the user a certain path of phases to follow. A tab-paneled interface also easily allows also going back and forth between different phases of the process, as MCDA process is typically an iterative one. However, also on this approach, a fully bias-free behavior cannot be assumed from the user. Nevertheless, in recent years this kind of approach has become more popular, and also in our analysis a few software provides a tab-paneled interface.

On application-specific software, the process support is usually expected to be much easier to implement, as a certain application area typically has at least certain patterns that each instance of this application follows. Of the application-specific software in our analysis, *MESTA* was such a software that was designed for a very specific application (forest planning) with predefined criteria. However, the applied method itself is based on setting acceptance thresholds for different criteria, which does not require much expertise from the user. Nevertheless, the software is a good example of providing hand-in-hand process guidance for a specific problem type with predefined criteria.

On the other hand, there are also such application-specific software in our analysis that have been implemented on quite a general level, although they are designed specifically for some certain application area. For example, in *PUrE2* software for air quality analyses, the decision analysis module is tightly integrated in the process model so that the data for it becomes directly from the life cycle assessment and spatial modeling modules. However, the use of the software still requires much MCDA expertise and in addition, also quite specific contextual expertise on life cycle assessment and spatial modeling. Similarly, *PlanEval* is a decision analysis module for a larger entity of forest planning tools, but also on this software, the decision analysis module has been implemented on quite a general level and its use does not differ much from the use of a typical general-purpose software.

3.3 Model construction (Table 3)

In terms of model construction, the software are generally quite similar to each other. For example, almost all the software provided a possibility to structure the criteria into a hierarchy. In practice, the hierarchy can be constructed either on a hierarchical manner (i.e. by adding criteria one-by-one under the selected elements of the current hierarchy) or by first freely creating different element and then connecting them graphically into a tree-like structure, and both these ways can be found on the software.

On evaluation the criteria-wise performance of the alternatives, almost all the software provide a matrix-like consequence table for inputting the criteria-wise data of the alternatives into the model. In addition to this, many software provide visual ways to input the data, for example, with a bar graph in which the width or height of the bars could be adjusted by dragging them with the mouse.

On the application-specific software, the model construction can be carried out in a more sophisticated way with the characteristics of the application in mind. For example, *PUrE2* software is designed for analyzing air quality and it provides, for example, a map-based interface for modeling the spreading of both indoor and outdoor pollutants. The software also provides a predefined list of air quality indicators that could be modified by the user. Another application-specific software, *MESTA*, provides similarly a predefined list of possible criteria for forest plans. Naturally, on general-purpose software, the use of this kind of predefined element lists in not possible.

3.4 Applied methods (Table 4)

Previously, the main stream in the software development has been to develop academic software for the very natural need of supporting some specific methodology that has been newly developed in the same academic unit. Some of the software in our analysis still belongs to this category. However, nowadays, many of the software are developed by commercial vendors to be truly general-purpose software, as besides being general-purpose in terms of application area, many software can also be seen to be general-purpose software also from the methodological viewpoint by providing a variety of methods even from different methodological schools. For example, almost half of the software in our analysis provide support for both AHP (or some other method based on pairwise comparisons) and MAVT/MAUT. In contrast, in the methodological research world, these methods are often districted quite clearly from each other and, apart

from a few exceptions, the dialogue between the researches of AHP and MAVT has been rare. There are also software that provide support for both outranking and MAVT/MAUT methodologies.

In terms of generality, *Analytica* is a software, which even takes one step further from being a general-purpose software, as it can be seen almost a visual programming language. It provides a spreadsheet interface is combined with an object-oriented approach to 'program' new functions or elements to the model. Thus, it can be seen as a combination of Excel and MATLAB with a graphical user interface. *Analytica* also provides a variety of distributions and element templates, and thus, at least in theory, it is possible to implement any method with it. This would naturally require very much expertise, but there are tens of different examples available that can be used as a template for the model.

Without few exceptions, all the software provide ways to visualize the preference elicitation. On MAVT, the basic approach is the one, where the user can adjust bars by dragging them with mouse, similarly as on the data input phase. However, on weights, the implementation of this is not as straightforward, as the sum of the weights is normalized to one. In this respect, there is some variability between the software as some software use non-normalized weights for the criteria, whereas some use normalized weights so that the weights not adjusted change accordingly. Some software even provide a freedom to select the normalization method. There are also software that provide a possibility to choose the MAVT weighting method among several different methods (e.g. SMART, Swing, Trade-offs). Some software (*D-Sight*, *M-MACBETH*, *MCDA-Res*) provide also tools for supporting outranking methods. However, apart from the method-specific features, the implementation of these software is very similar to the MAVT-based software.

On software providing AHP or other pairwise comparison method, there a two main approaches, how the pairwise comparison is implemented. In the first one, the pairwise judgments between the criteria are inputted in a matrix where each criterion is evaluated against each other criterion. Another approach is that all the possible combinations of criteria pair are presented with a list and on each of these the decision maker should define the importance of the first criterion compared to the second one. In practice, this is typically implemented with a slider in between these two criteria ranging, for example, from 9 to 1 to 9.

Some software provide explicit support for modeling uncertainty/imprecision. One approach to model imprecision is to use intervals that describe the limits of allowed variation for the parameters, or some inequality constraints. This approach is supported by *DecideIT*, *GMAA*, *WINPRE* and *V.I.P. Analysis*, which all have their grounds on academic research on corresponding methodologies. Another way is to allow the use of distributions on the model parameters, and this approach is supported by *GMAA* and *PUrE2*.

We have also included three software (*DecideIT*, *Decision Tools* and *TESLA*) based on the decision tree approach into our analysis, although this methodology differs slightly from the other methodologies. However, we thought that it would still be useful to also analyze some these especially in terms of how the decision tree is constructed. Unfortunately, in this respect, these software do not give much new, as the decision construction approach they provide is quite similar to the hierarchical construction approach of value trees.

3.5 Analysis of the results (Table 5)

All the software in the analysis provide at least some kind of visual graphs to present the results. The most common approach is the overall value bars that can be divided into segments indicating the effects of various criteria to the overall results. Another approaches found at least in some software include radar/spider profiles of the alternatives, tornado plots, thermometer graphs, score profiles and pie graphs. In all the software based on interval methods, the results are naturally presented as intervals and on some of them also dominance relations, potential optimality information and/or optimality regions are presented.

The most common sensitivity analysis approach is the traditional one-way sensitivity analysis that can be found on most of the software. In addition, a few software provide some kind of statistical approaches for carrying out the sensitivity analysis. These are based on, for example, applying various distributions on model parameters and carrying out simulation of the overall results with these. As a result, one gets, for example, probabilistic rankings of the alternatives or percentages on how often some alternative dominates some other one. On interval methods, the use of intervals itself can be seen as a kind of sensitivity analysis, but one step further is to adjust these and analyze the changes in the results online, which can be seen as an interactive sensitivity analysis. *GMAA s*oftware also provide a SMAA like analysis of weight regions to analyze the sensitivity of the weights.

A some kind of x-y graph can also be found on most of the software. In these graphs, one can select one criterion on each axis and plot the alternatives on this graph to compare how these manage in terms of these criteria. Some software even provide a third dimension with the size of the ball indicating the alternative.

A few software provide a possibility to construct a written report that shows the main results and explains these to the user.

3.6 Support for the group processes (Table 6)

A few software provide explicit functionalities to support group facilitation. For example, *1000Minds* provides an opportunity to carry out decision surveys and online voting after analyzing the other stakeholders' models on the web. *D-Sight*, *MakeItRational* and *Web-HIPRE* provide an opportunity to, for example some weighted mean method to combine individual weights given by the decision makers to some common group preferences. On *PlanEval* the stakeholders can each give their own weights, which can be compared visually.

Interval methods can be use as an implicit way to support group decision making by including the judgments of different decision makers into intervals describing the variation of the judgments. All the software supporting interval methods can be used in this way also to support group decision making. However, as the support is not explicit, naturally, some facilitation is needed.

3.7 Other characteristics (Tables 7 and 8)

Many software provide a possibility to import and/or export the data and results, for example, in plain text or to Excel. In addition, many software have 'Excel-like' interfaces to input the data, and this familiarity of the interface might reduce the step of taking the software into the use. Examples of this are *Promax* and *Pure2*, which have Office 2010 like interfaces with a ribbon. *Decision tools* software has even been implemented as an Excel add-in so that the software functionality is embedded in the Excel menus (or Ribbon in newer Excel versions) and toolbars.

Most of the software are standalone applications, but some software (1000Minds, MESTA, Web-HIPRE) are implemented with a Web interface and some (*MakeItRational* and *V.I.S.A. Decisions*) have both standalone and online Web versions available. In addition, *D-Sight* has a demo version available on the Web.

4. Discussion

In general, the software are quite similar to each other. The basic structure of MCDA (problem construction – criteria – alternatives – analysis of the results – sensitivity analysis) can be found practically in all the software, and also to main lines of carrying out the process seem to be the same. This is quite expected, as MCDA methods have now been developed and used for decades, and during that time there has been established certain standards for carrying out the process.

On general-purpose software the trend seems to be nowadays, to provide several different ways to model the problem and analyze the results. On application-specific software the methods are more tailored for the purposes of the application, but also these software typically provide, for example, various different graphs to analyze the results.

4.1 Designing an application-specific software for the EIA process

One of the objectives of the IMPERIA project is to develop an MCDA software to support the EIA process. Although the application areas of EIA can vary considerably from each other, the principles of applying EIA are usually quite the same. Thus, the applied EIA process is quite a similar regardless of the project type. Consequently, although our aim is to develop general-purpose software for EIA, the software is likely to also have typical characteristics of application-specific software.

In November 2012, we arranged an IMPERIA workshop to find out the needs of EIA for the MCDA software. The targeted users are EIA experts and authorities who are going to apply MCDA methods in their assessment process, but who do not necessarily have much experience on MCDA. Thus, a very natural basic need of the software is the easiness of its use. However, in practice, certain expertise is needed to use the MCDA methods properly and thus it is not straightforward to implement easy-to-use software that simultaneously provides advanced support for the method. On the other hand, we think that on homogeneous processes such as EIA, it is possible to develop software that guide the user hand-in-hand through the process without compromising the sophistication of the support. One of the tasks in the IMPERIA project is to consider how this kind of support could be implemented in practice.

Another issue that came up in the workshop is the need of including MCDA in the EIA process in a very early phase of the process, and already in the assessment program phase, there have to be made choices that affect the whole future process. In addition, the different interest and stakeholder groups also have different objectives, and the earlier these are considered, the better they could be expected to be integrated in the process. To take all these needs into account, the MCDA software should, also, provide features that support the process from the start of the process.

Yet another issue that came up was the need for the process support. Often, the MCDA software are considered just as calculation and visualization tools for supporting the mathematical modeling of the methods. However, in practice, the MCDA can be much more than that and at best MCDA is tightly integrated in the process so that the whole planning process is implemented according to the principles of MCDA. In this respect, it is expected to be very useful to have some support for a structured progression of the process. One should, however, note that in practice the process is often iterative, which should also be taken into account.

As one of the main venues for improving the EIA processes, many experts and practitioners have seen improving the practices of impact significance assessment, which also came up in our workshop. In this respect, we think that MCDA has a lot of potential in providing methods that could make the impact significance assessment more structured and transparent. However, implementing the process in practice should be carefully planned so that the special characteristics of EIA would be taken into account. Another

contextual issue on which MCDA can provide additional value is identifying the chains between the direct and indirect effects of alternatives and providing tools to make the evaluation of the effect clearer and more versatile. Yet, another important development area is the analysis of the related risks, and also in this respect structured and transparent methods, and consequently the supporting software, are expected to be useful. In IMPERIA, our aim is to focus on all of these issues in the future development work of the MCDA supported EIA processes and the software.

4.2 Innovative features of the software from the viewpoint of the IMPERIA project

We also analysed whether there are such innovative features in the software that could be useful in our MCDA tool development in the IMPERIA project. For example, as mentioned above, the support for an early phase of the process is needed. In this respect, the brainstorming feature of *Criterium Decision Plus* could be useful in the sketching of the elements of the problem as well as the relations between these.

In terms of developing application-specific software, our software survey did not reveal such novel features that could be directly applied in our software. The main additional value of the survey in this respect was to see that the implementation of the methods can be made on the conditions of the application and that it is possible to tailor the method for specific applications in a way that takes the characteristics of the application into account. These software also showed that it is possible to implement some kind of process support, although also in this respect it might not be possible to directly apply these methods.

In terms of process support, the Tab-panels applied in many software seemed to be an applicable approach that could also be utilized in our software. On one hand, they provide a clear indication of the course of the process but on the other hand they allow room for going back in the previous phases of an iterative process. Nevertheless, some help should be provided for each phase of the process and in this respect it could be useful to use approaches like the decision wizard of *V.I.S.A. Decisions* in which the instructions given follow the course of the process.

The visualization of the results is also likely to be in an important role in our software, as it can help understanding the results. In the impact significance assessment of EIA, the overall impacts are formed of different dimensions of the impacts, such as the magnitude and sensitivity of the impact. In this respect, especially the two-dimensional (or three-dimensional e.g. with the size of the marker being the third dimension) graphs could be a very useful way to visualize the different dimensions, which consequently is likely to help understanding the overall impacts.

5. Conclusions

In this paper, we have compared various MCDA software in terms of the features they provide. In general, the structures of the software are very similar to each other. This is quite natural as all of them follow the general structure of the MCDA process, which in recent decades, has established some standard procedures to follow. There are, however, some differences on what methods and what kind of ways to present the results the software provide. However, also in this respect the implementations of different methods are generally quite similar to each other.

A general trend in the software seems to be on being multi-purpose software providing several different methods for various cases. On one hand, this allows the application of the software for a wide variety of different cases, but on the other hand, this freedom also requires certain expertise from the user to use the software. We also analysed some application-specific ones, and the implementation of these showed that on homogeneous application areas it is also possible to develop software providing such guidance with which users having only little experience are also able to go through the process. IMPERIA project aims to make the EIA practices more transparent and homogeneous. In this respect, the development of an EIA-specific software along with developing the EIA practices seems to be a natural extension to support these practices and has, thus, good premises to succeed.

In terms of developing tools for supporting the EIA process, the software analysed in this survey provide some ideas that are worth considering. First, a tab-panelled user interface seems to be quite useful and a natural way to present the process. That is, on one hand, it gives an indication of the phases of the process and guidelines for carrying out the process, but at a same time allows going back and forth between the phases, which is often needed in an MCDA process. Second, the various ways to visualize the process give some ideas for the EIA tool, and especially, the two or more dimensional graphs are expected to be useful. Naturally in practice, the implementation of these features in our software should be planned carefully to also take the characteristics of EIA into account.

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Weistroffer, H.R., Smith, C.H., Narula, S.C. (2005). Multiple criteria decision support software. In: Figueira, J., Greco, S., Ehrgott, M. (eds), Multiple Criteria Decision Analysis: State of the Art Surveys Series, Springer: New York, 989–1018.

Web Links

EWG-MCDA – EURO Working Group on Multicriteria Decision Aiding– MCDA Software:
http://www.inescc.pt/~ewgmcda/Software.html
http://www.cs.put.poznan.pl/ewgmcda/index.php/software

OR/MS Today – Decision Analysis Software Survey (October 2012):
http://www.orms-today.org/surveys/das/das.html

Wikipedia – Decision-making software:
http://en.wikipedia.org/wiki/Decision-making_software

Appendix A

Table 1. General information

Software	Full name/Slogan	Vendor	Vendor's description
1000Minds	-	1000Minds Ltd.	1000Minds helps with decision-making, prioritization and discovering stakeholder preferences. Depending on your application, 1000Minds can also help you think about the 'value for money' of alternatives you're considering and allocate budgets or other scarce resources. As well as stand-alone decision tools, we offer customisable processes to include potentially 10s or 100s (even 1000s!) of participants in a variety of group decision-making activities. 1000Minds applies our patented PAPRIKA method – an acronym for 'Potentially All Pairwise RanKings of all possible Alternatives'.
Analytica	Analytica - Beoynd the Spreadsheet	Lumina Decision Systems, Inc.	If you use spreadsheets for building business models or policy analysis, Analytica will be a revelation: Its intuitive influence diagrams let you create a model the way you think, and communicate clearly with colleagues and clients, Its Intelligent Arrays let you create and manage multidimensional tables with an ease and reliability unknown in spreadsheets, Its efficient Monte Carlo lets you quickly evaluate risk and uncertainty, and find out what variables really matter and why.
Craft	Comparative Risk Assessment Framework and Tools	USDA Forest Service	CRAFT - Comparative Risk Assessment Framework and Tools - is designed to lead natural resource managers through an integrated assessment of the risks, uncertainties, and trade-offs that surround forest and rangeland management. CRAFT helps to identify and clarify objectives, design alternatives, assess probable effects, and compare and communicate risks.
Criterium Decision Plus 3.0	The leading 32-bit Windows decision manager that helps you move quickly to a decision and successfully promote your recommendations.	InfoHarvest	Use Criterium Decision Plus 3.0 to manage the entire decision process. Applying a structured methodology to decision making, Criterium DecisionPlus helps you make precise, thoughtful, and completely supportable decisions - Quickly and efficiently! Direct Tradeoffs, larger models, powerful graphics and extensive options means that CDP 3.0 supports insightful, persuasive decision making faster and for more complex models than ever.
DecideIT	The decision tool that handles imprecision	Preference	Preference's decision tool *Decide*IT enables you to carry out reliable risk and decision analyses. *Decide*IT packages state-of-the-art decision methodologies and mathematical analysis in an efficient and user friendly software. The decision tool *Decide*IT comes with an easy-to-use graphical user interface in which decision trees together with criteria hierchies constitute the main schematic overview of the decision architecture. Such models are very useful in cases of complex decisions, as they provide the decision maker and decision analyst with a graphical presentation of the decision situation at hand and shows the internal relations between options, objectives, and uncertain parameters.
Decision Tools	Integrated Risk and Decision Analysis in Excel	Palisade Corporation	The DecisionTools Suite is an integrated set of programs for risk analysis and decision making under uncertainty that runs in Microsoft Excel. The DecisionTools Suite includes @RISK for Monte Carlo simulation, PrecisionTree for decision trees, and TopRank for "what if" sensitivity analysis. In addition, the DecisionTools Suite comes with StatTools for statistical analysis and forecasting, NeuralTools for predictive neural networks, and Evolver and RISKOptimizer for optimization. All programs work together better than ever before, and all integrate completely with Microsoft Excel for ease of use and maximum flexibility.
D-Sight	The most innovative	D-Sight	D-Sight Web is a collaborative decision-making platform that helps

	decision-making software solutions		you to solve challenges, analyze data, and drive results by bringing people together to make a decision. It is designed as an interactive and intuitive interface so that you can easily navigate through your project and structure in the best way your decisions. D-Sight Desktop is a dedicated software solution to support your decision-making processes. It provides a framework allowing decision makers to evaluate different alternatives against several criteria and identify the best solution.
GMAA	Generic Multi-Attribute Analysis	Universidad Politécnica de Madrid	GMAA is a DSS based on an additive multi-attribute utility model that accounts for incomplete information concerning the inputs. The system is intended to allay many of the operational difficulties involved in the DA cycle, which can be divided into four steps: structuring the problem; identifying the feasible alternatives, their impact and uncertainty; quantifying preferences; evaluating strategies and performing *Sensitivity Analysis*.
Hiview 3	-	Catalyze Ltd	Hiview3 is a PC-based decision modelling tool that supports the appraisal and evaluation of options. It is equally effective for group decision making, such as decision conferences and for individual decisions. With a host of user-defined features, Hiview3 can be configured to address a variety of problem areas, supporting your specific business objectives. Hiview3 enables users to make effective decisions in areas such as Capital Projects, Policy Setting, Strategy Selection, Relocation Issues, Problem Solving and Budget Resourcing.
Logical Decisions	Software, consulting and training for more effective decisions	Logical Decisions	Logical Decisions lets you evaluate choices by considering many variables at once, separating facts from value judgments, and explaining your choice to others. Logical Decisions uses techniques from the field of decision analysis to help you make more effective decisions. Logical Decisions provides a variety of methods for assessing attribute weights, has many results displays and empowers you with many sophisticated features.
M-MACBETH	Measuring Attractiveness by a Categorical Based Evaluation Technique	Bana Consulting Lda	MACBETH is an interactive approach that requires only qualitative judgements about differences to help a decision maker or a decision-advising group quantify the relative attractiveness of options. It employs an initial, interactive, questioning procedure that compares two elements at a time, requesting only a qualitative preference judgement. As judgements are entered into the software, it automatically verifies their consistency. A numerical scale is generated that is entirely consistent with all the decision maker 's judgements. Through a similar process weights are generated for criteria.
MakeIt-Rational	MakeItRational – Analytical Hierarchy Process Software	MakeItRational	MakeItRational is a decision support software based on Analytic Hierarchy Process (AHP). AHP is a method of multi-criteria evaluation which organizes and simplifies decision-making. Use MakeItRational software for supporting complex and tough decisions.
MCDA-Res	The MCDA Tool Kit	University of Aegean	The current Software Decision Tool aims at providing guidelines that enable integrated Analysis of RES investments. This process will aid in deciding about the appropriate project to be implemented.
MESTA	MESTA - Decision Support Tool	Metla	MESTA enables you to perform holistic and multi-objective decision analysis based on selected decision criteria. During the use of the application you will define your own acceptance thresholds for each decision criteria.
OnBalance	-	Quartzstar Software Ltd.	OnBalance is based on Multi Criteria Decision Analysis (MCDA) which helps separate what you measure from how you value it. The interface is specifically designed for group decision making, as most of the difficult decisions are between good schemes, each supported by one or more managers.
PlanEval	-	Swedish	PlanEval (for "plan evaluation") is a tool for multi-criteria decision

		University of Agricultural Sciences (SLU)	analysis. Alternative plans generated in PlanWise can be compared systematically by structuring the decision problem into components, put relative weights on these components either by pairwise comparisons or direct weighting, and finally conmputing a total (relative) value for each plan. The method used is called Analytic Hierarchy Process (AHP).
Promax	-	Cogentus Consulting Ltd	Promax is a software support tool that enables organisations to robustly underpin decisions. Unlike other tools, such as a spreadsheet, what sets it apart is that it is a purpose made decision tool. It is leading edge with massive flexibility, powerful visualisations all backed up by academic rigour.
PUrE2	PUrE2 Software	PUrE INTRAWISE	Building on the original PUrE Sustainable Assessment Software the PUrE Intrawise project has improved and added many new features and additional functionality to the PUrE2 Software. Alongside the existing pollutant and impact modelling capabilities built into the PUrE software building models and indoor air quality models have been added. In addition existing models and tools such as Life Cycle Assessment, Human Health Analysis and Multi-Criteria Decision Analysis have been substantially improved.
TESLA	-	Quintessa	TESLA is a software tool that aims to support decision makers when faced with complex decision problems. It provides a means to break a decision down into a hierarchical structure, simplifying the problem and presenting it in such a way that information can be easily gathered and categorised. TESLA does not automate the decision-making process but provides valuable support to the decision maker.
The Decision Deck project	-	Decision Deck Consortium	The Decision Deck project aims at collaboratively developing Open Source software tools implementing MultiCriteria Decision Aid (MCDA) techniques which are meant to support complex decision aid processes. One of the main features of these software solutions are that they are interoperable in order to create a coherent ecosystem.
V.I.P. Analysis	V.I.P. Analysis - Variable Interdependent Parameters Analysis	University of Coimbra	The V.I.P. (Variable Interdependent Parameters) Analysis software has been built to support the selection of the most preferred alternative among a list, considering the impacts of each alternative on multiple evaluation criteria. It is based on an additive aggregation model (value function), accepting imprecise information on the value of the scaling coefficients (a.k.a. scaling constants, which indirectly reflect the relative importance of the each criterion).
V.I.S.A. Decisions	Visual representations of information, Interactive results charts and more, Sensitivity Analysis to identify and illustrate the effect of changing values.	SIMUL8 Corporation Ltd	V·I·S·A software is for decisions with multiple, tough to balance, factors; for decisions where no option matches all of the criteria perfectly; or for decisions where more than one person has a say in how the decision is made. It does not tell you the "right answer", it lets everyone involved see for themselves what the best overall decision is, weighing up all the factors using a considered and sound process. V·I·S·A also documents how that decision was made and why it was the right outcome for future reference.
Web-HIPRE	HIerarchical PREferences on the Web	Systems Analysis Laboratory, Aalto University	Web-HIPRE is a web-version of the HIPRE 3+ software for decision analytic problem structuring, multicriteria evaluation and prioritization.
WINPRE	Imprecise Preferences for Windows	Systems Analysis Laboratory, Aalto University	Winpre is an implementation of techniques based on the propagation of imprecise preference statements in hierarchical weighting. PAIRS and Preference Programming methods are both implemented in Winpre.

Table 2. Process support

Software	General-purpose software	Process support	Hand-in-h-hand guidance	Level of expertise required	Special characteristics
1000Minds	Y	Y	Y	2	Tab-based Web browser interface
Analytica	Y	N	N	3	Interface of spreadsheets extended to visual model
Craft	N	Y	Y	1	Guidelines for carrying out the process
Criterium Decision Plus 3.0	Y	N	N	3	
DecideIT	Y	N	N	3	
Decision Tools	Y	N	N	3	
D-Sight	Y	Y	N	2	Tab-based interface
GMAA	Y	N	N	3	
Hiview 3	Y	N	N	3	
Logical Decisions	Y	N	N	3	
M-MACBETH	Y	N	N	3	
MakeItRational	Y	Y	N	2	Tab-based guidance through the phases of the process
MCDA-Res	Y	Y	Y	2	Guide how to carry out the process
MESTA	N	Y	N	1	Page-to-page process
OnBalance	Y	N	N	3	
PlanEval	N	N	N	3	Tab-based interface
Promax	Y	Y	N	3	Office 2010 like interface
PUrE2	N	Y	N	3	
TESLA	Y	N	N	3	
The Decision Deck project	-	N	N	-	
V.I.P. Analysis	Y	N	N	3	
V.I.S.A. Decisions	Y	Y	Y	3	Decision wizard
Web-HIPRE	Y	N	N	3	
WINPRE	Y	N	N	3	

Table 3. Model construction

Software	Hierarchical model	Consequences table	Visual scoring	Special characteristics
1000Minds	N	Y	N	Basically just a consequence table
Analytica	Y	Y	Y	Object-oriented creation of models
Craft	N	Y	N	Basicly just guidelines for creating a good DA model. Excel-sheets for a systematic listing of different elements.
Criterium Decision Plus 3.0	Y	Y	Y	Brainstorming window
DecideIT	Y	N	Y	
Decision Tools	Y	Y	N	Hierarchical decision tree model
D-Sight	Y	Y	N	Grouping based hierarchical model in the Web version
GMAA	Y	Y	Y	
Hiview 3	Y	N	Y	Input with numbers or classification-based data.
Logical Decisions	Y	Y	Y	
M-MACBETH	Y	Y	Y	
MakeItRational	Y	Y	Y	
MCDA-Res	-	-	-	A collection of software mainly for outranking methods
MESTA	N	Y	Y	
OnBalance	Y	Y	Y	
PlanEval	Y	Y	Y	
Promax	Y	Y	Y	
PUrE2	Y	Y	Y	Predefined list of sustainability indicators (with a possibility to add own.) classified into three categories.
TESLA	Y	N	Y	Probability estimates for different actions
The Decision Deck project	-	-	-	
V.I.P. Analysis	N	Y	Y	Constraints on the weights
V.I.S.A. Decisions	Y	Y	Y	
Web-HIPRE	Y	Y	Y	
WINPRE	Y	Y	Y	

Table 4. Criteria weighting

Software	Visual weighting	AHP/Pairwise comparison	MAUT/MAVT	Swing	Outranking	Modeling of uncertainties/imprecision	Decision trees	Special characteristics
1000Minds	N	Y	Y	N	N	N	N	PAPRIKA method based on pairwise comparisons
Analytica	Y	N	Y	Y	N	Y	N	Object-oriented visual interface, with which one can implement practically any method. Various distributions available.
Craft	N	N	N	N	N	N	N	No MCDA methods included
Criterium Decision Plus 3.0	Y	Y	Y	Y	N	N	N	AHP weighting and direct AHP weights
DecideIT	Y	Y	Y	N	N	Y	Y	Modeling of uncertainties with intervals, or inequality relations
Decision Tools	N	N	N	N	N	Y	Y	Decision trees
D-Sight	Y	N	Y	N	Y	N	N	PROMETHEE and MAUT methods
GMAA	Y	N	Y	N	N	Y	N	Imprecise judgments with intervals, certainty equivalent methods and probability equivalent methods
Hiview 3	Y	N	Y	Y	N	N	N	Macbeth method among others
Logical Decisions	Y	Y	Y	Y	N	N	N	
M-MACBETH	Y	Y	Y	N	Y	N	N	Macbeth method
MakeItRational	Y	Y	Y	N	N	N	N	Basic AHP based weighting
MCDA-Res	-	-	-	-	Y	-	-	A collection of software mainly for outranking methods
MESTA	N	N	N	N	N	N	N	Setting of thresholds and analyzing which alternatives fulfill these
OnBalance	Y	N	Y	Y	N	N	N	
PlanEval	Y	Y	Y	Y	N	N	N	
Promax	Y	Y	Y	Y	N	N	N	
PUrE2	Y	Y	Y	Y	N	Y	N	Modeling of uncertainty with distributions of model parameters
TESLA	Y	N	N	N	N	Y	Y	Decision tree approach with evidence based updating
The Decision Deck project	-	-	-	-	-	-	-	
V.I.P. Analysis	Y	N	Y	N	N	Y	N	Constraints on the weights
V.I.S.A. Decisions	Y	N	Y	Y	N	N	N	
Web-HIPRE	Y	Y	Y	Y	N	N	N	
WINPRE	Y	Y	Y	Y	N	Y	N	Imprecise judgments with intervals, PAIRS and preference programming methods

Table 5. Analysis of the results

Software	Visual graphs	Overall values	Sensitivity analysis	x-y graphs	Written report	Special characteristics
1000Minds	Y	Y	Y	Y	Y	Radar graph, overall values, criteria-wise values
Analytica	Y	Y	Y	Y	N	Tornado graph
Craft	N	N	N	N	N	No analysis of the results
Criterium Decision Plus 3.0	Y	Y	Y	Y	N	Various graphs (Scatter plot, Spider graph, etc.)
DecideIT	Y	Y	Y	Y	N	Probabilistic rankings and dominances, expected values
Decision Tools	Y	N	Y	Y	Y	Various statistical analyses and visual tools
D-Sight	Y	Y	Y	Y	N	Various graphs
GMAA	Y	Y	Y	Y	N	Overall value intervals for the alternatives, dominance and potential optimality
Hiview 3	Y	Y	Y	Y	Y	A set of basic MCDA analysis tools
Logical Decisions	Y	Y	Y	Y	Y	Various graphs
M-MACBETH	Y	Y	Y	Y	N	One-way sensitivity analysis and thermometer, rovustness analysis with dominances
MakeItRational	Y	Y	Y	Y	Y	A set of basic MCDA analysis tools
MCDA-Res	-	-	-	-	-	A collection of software mainly for outranking methods
MESTA	Y	N	N	N	N	Setting of thresholds and analyzing which alternatives fulfill these
OnBalance	Y	Y	Y	Y	N	Various graphs
PlanEval	Y	Y	N	N	Y	Basic overall values
Promax	Y	Y	Y	Y	N	Various graphs
PUrE2	Y	Y	Y	N	N	Uncertainty analysis of rankings obtained from simulation of distributions
TESLA	Y	Y	Y	Y	Y	Various methods to analyse the decisions and relateed uncertainties
The Decision Deck project	-	-	-	-	-	
V.I.P. Analysis	Y	Y	Y	Y	N	SMAA-like sensitivity analysis
V.I.S.A. Decisions	Y	Y	Y	Y	Y	A set of basic MCDA analysis tools
Web-HIPRE	Y	Y	Y	N	N	A set of basic MCDA analysis tools
WINPRE	Y	Y	Y	N	N	On-line sensitivity analysis, i.e. consequences of changes are instantly shown in results, Pairwise dominances shown

Table 6. Group decision support

Software	Group model	Special characteristics	Excel-model
1000Minds	Y	Decision survey, online voting	N
Analytica	N	No explicit group support	Y
Craft	N	No explicit group support	Y
Criterium Decision Plus 3.0	N	No explicit group support	Y
DecideIT	N	No explicit group support	N
Decision Tools	N	No explicit group support	Y
D-Sight	Y	Weighting of group members	Y
GMAA	N	No explicit group support, implicit with intervals	N
Hiview 3	N	No explicit group support	N
Logical Decisions	N	No explicit group support	N
M-MACBETH	N	No explicit group support	N
MakeItRational	Y	Averaging of individual results into group result	N
MCDA-Res	-		-
MESTA	N	No explicit group support	N
OnBalance	N	No explicit group support	N
PlanEval	Y	Stakeholders can give their own weights, which can be compared visually	N
Promax	N	No explicit group support	N
PUrE2	N	No explicit group support	N
TESLA	N	No explicit group support	Y
The Decision Deck project	-		
V.I.P. Analysis	N	No explicit group support	N
V.I.S.A. Decisions	N	No explicit group support	N
Web-HIPRE	Y	Weighted group model	N
WINPRE	Y	Intervals can represent a variety of individual judgments	Y

Table 7. Other information I

Software	Description and characteristics of the software	Application areas	Useful or innovative features from the EIA/MCDA viewpoint
1000Minds	Web-based software with a tab-based interface. Preferences with (numerous) pairwise questions on criteria. Various ways to analyze the results. Shareng the results on the net and possibility for voting or surveys.	General	Tab-based web interface.
Analytica	Object-oriented visual interface, with which one can implement practically any method. Various graph-building . Pre-defined modules available, for example, for MAUT, optimization, risk analysis. Various distributions available.	General	Object-oriented interface. Visual graph-building possibilities.
Craft	Basicly a generic Excel-sheet, where one can list alternatives and impact matrix. No graphical support nor analytical tools.	Forest management	The idea of Excel-sheet. However, this approach is just a sheet without any functionality
Criterium Decision Plus 3.0	Basic MAVT software with AHP functionality	General	Brainstorming, various graphs
DecideIT	MCDA software providing both value and decision tree approaches. Use of intervals and inequality relations in weighting. Probablisitic analysis of imprecise results	Generic	Modeling of uncertainties with intervals
Decision Tools	Decision Tools provides a set of Excel add-ins mainly for statistical analysis of decisions. The add-ins include: 1) @RISK for risk analysis using Monte Carlo simulation, 2) PrecisionTree for decision analysis with decision trees and influence diagrams, 3) TopRank for "what if" sensitivity analyses, 4) NeuralTools for predictive analysis with neural networks, 5) StatTools for forecasting and statistical analyses, 6) Evolver for optimization, 7) RISKOptimizer for combining optimization under uncertainty with Monte Carlo simulation	Generic	The use of various distirbutions to account for uncertainties via simulation. Decision tree approach. Excel-based user interface provides a flexible model construction, but requires some expertise
D-Sight	Basic MCDA software with PROMETHEE and MAUT methods. Both Web and desktop versions available.	Generic	Tab-based interface.
GMAA	MAUT software with a possibility to use intervals to model imprecision	Generic	Use of intervals
Hiview 3	Pretty much like Web-HIPRE. Various different graphs and MACBETH method.	Generic	Selection of x-y graphs visually
Logical Decisions	Basic MAVT software with AHP functionality	Generic	
M-MACBETH	MAVT software that support Macbeth method, various graphical ways to assess the parameters	Generic	Various graphs
MakeItRational	A basic tab-based interface for AHP analysis. Group model provided	General	Tab-based interface
MCDA-Res	MCDA-res provides guidelines for carrying out MCDA process in renevable energy resource (RES) cases. It is practically an interactive list of guidelines and demostrations of them in example cases, and with links to small software with which the cases were carried out.	Renevable energy resources	The idea of the support being a resource collection
MESTA	A software based on setting thresholds to criteria and analyzing which alternatives fulfill these	Forest planning	A tailored software for forest planning. Use of thresholds may be useful

			in EIA.
OnBalance	Basic MAVT software	Generic	
PlanEval	MCDA package for the PlanEval simulation and optimization software for forest planning	Forest planning	Stakeholders can give their own weights, which can be compared visually
Promax	Basic MAVT software	Generic	Office 2010 like interface with tabs
PUrE2	Software for supporting air quality modeling. Besides decision support block provides blocks for spatial modeling and life cycle assessment, that provide various modeling capabilities and information for decision support.	Indoor air quality	Application specific software for air quality modeling. Life cycle assessment and spatial models provide info for decision support block. Predefined set of indicators.
TESLA	A software with decision tree approach and evidence based updating of probabilities	Generic	Two-dimensional confidence vs. uncommitted belief graphs
The Decision Deck project	Open Source software. Includes currently a few freeware decision support modules.	Generic	Open source
V.I.P. Analysis	MAVT software with a possibility to give constraints on weights. Sensitivity analysis with SMAA-like figures of optimal regions	Generic	SMAA-like analysis of weights
V.I.S.A. Decisions	Basic MAVT software	Generic	Both Web-based and desktop interfaces
Web-HIPRE	Basic HIPRE	Generic	Web-based interface
WINPRE	MAVT software with a possiility to use intervals to model imprecision with PAIRS and preferenceprogramming methods	Generic	Modeling of uncertainties with intervals

Table 8. Other information II

Software	Other comments	People/instances behind the software	Price
1000Minds	Numerous online demos available	Paul Hansen, Franz Ombler	Free for academic purposes, other negotiable
Analytica	A combination of Matlab and Excel with GUI.	Max Henrion	Professional version $995
Craft		US Forest Service	-
Criterium Decision Plus 3.0	Free 'student version' available	Philip Murphy	$895.00
DecideIT		Love Ekenberg, Mats Danielson	Free for academic use. Commercial licence 1900€ + 900€/year.
Decision Tools	Decision Tools is a set of features to make analyses on Excel-based data. MCDA modeling is not explicitly supported except decision trees.	-	Depends on the licence (Stand-alone single-user licence ~£2000)
D-Sight	Free web and desktop demos available. Web version is a reduced version of the desktop version	Yves De Smet	Academic 249€, corporate from 1990€
GMAA	-	Sixto Rios-Insua, Antonio Jimenez, Alfonso Mateos	Available free of charge for academic purposes
Hiview 3		Larry Phillips	950€ (Standard single-user licence with 1-year support)
Logical Decisions	The software crashed during testing. The example model did not work	-	1 installation $895.00
M-MACBETH		Carlos Bana e Costa, Jean Marie De Corte, Jean-Claude Vansnick	Free demo available, academic licence €175, professional €1750
MakeItRational	A free online demo available	?	Monthly fee of $17-100 depending on the project size
MCDA-Res	Package was made within an EU project similar as ours	University of Aegean	
MESTA		Pekka Leskinen, Mikko Kurttila	Free?
OnBalance	Quartzstar has had close links with Krysalis	-	Charityware
PlanEval		Swedish University of Agricultural Sciences (SLU)	Free
Promax	-	-	Standard version £495
PUrE2	More information about LCA and sparial block from user guide	Adisa Azapagic	Free of charge for non-profit making applications
TESLA	Free demo available. They also claim to have an MCDA software, but there is no demo available.	A consultant company	?
The Decision Deck project		Vincent Mousseau	Open source
V.I.P. Analysis		Luis C. Dias, João Climaco	Distributed for free

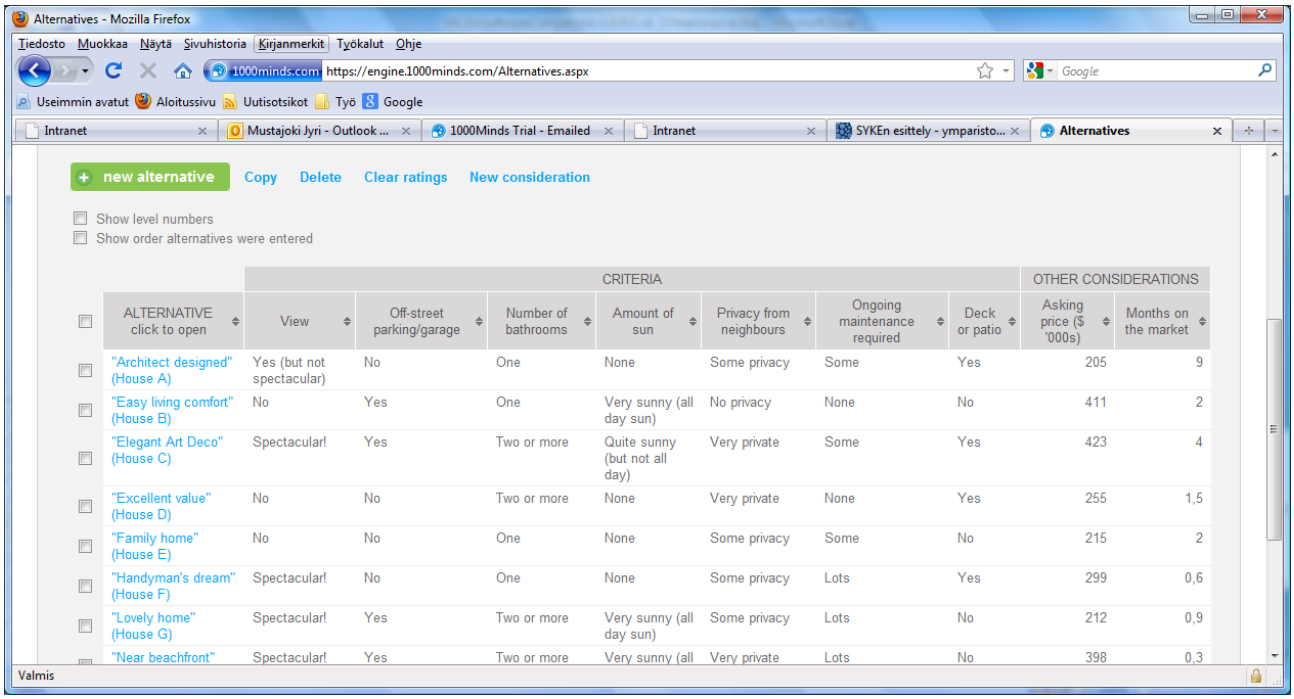
V.I.S.A. Decisions		Valerie Belton	Standard version (Includes standalone application and web-based version) $495
Web-HIPRE	"HIPRE people are good people"	Raimo P. Hämäläinen, Jyri Mustajoki	Free for academic purposes
WINPRE		Raimo P. Hämäläinen, Jyri Helenius	Freely available for academic purposes

Table 9. Web pages of the software

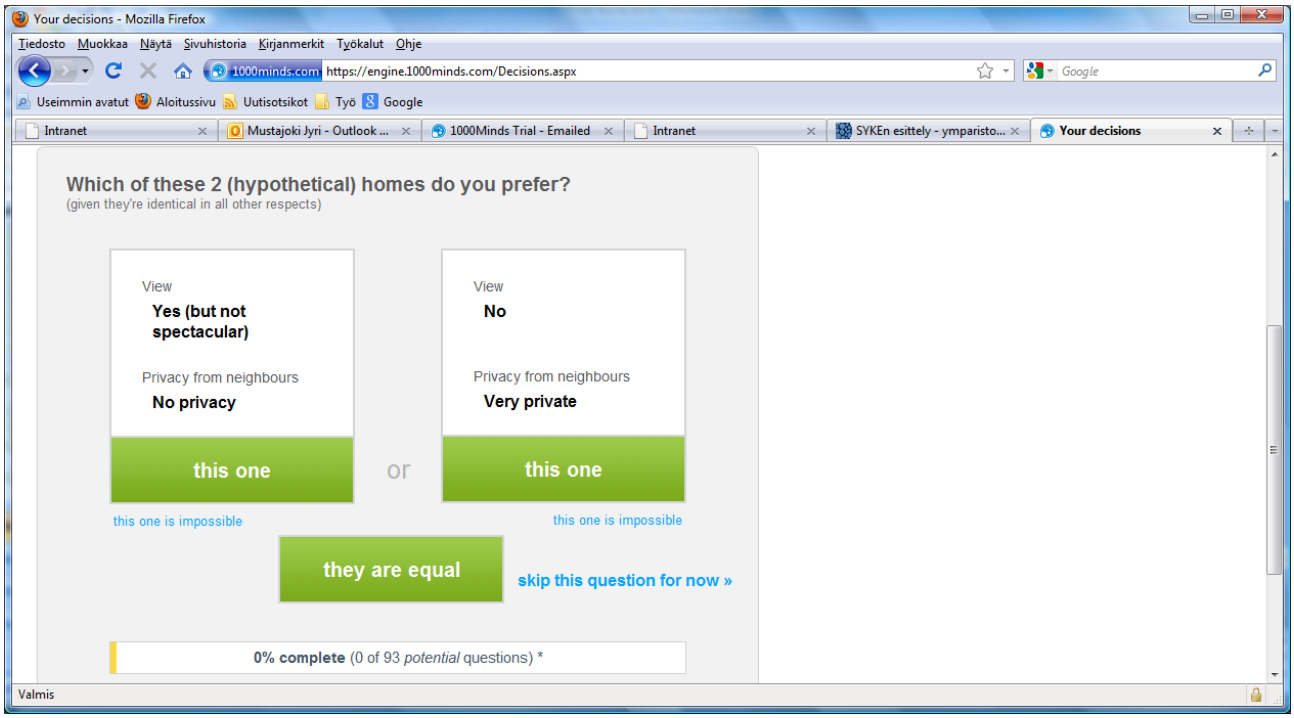
Software	WWW
1000Minds	http://www.1000minds.com
Analytica	http://www.lumina.com/why-analytica/
Craft	http://www.fs.fed.us/psw/topics/fire_science/craft/craft/
Criterium Decision Plus 3.0	http://www.infoharvest.com/ihroot/infoharv/products.asp
DecideIT	http://www.preference.nu/?l=decideit&lan=en
Decision Tools	http://www.palisade.com/decisiontools_suite/
D-Sight	http://www.d-sight.com/
GMAA	http://www.dia.fi.upm.es/~ajimenez/GMAA
Hiview 3	http://www.catalyze.co.uk/
Logical Decisions	http://www.logicaldecisions.com
M-MACBETH	http://www.m-macbeth.com
MakeItRational	http://makeitrational.com/multi-criteria-evaluation
MCDA-Res	http://www.aegean.gr/environment/energy/mcda/MCDA_default.htm
MESTA	http://mesta.metla.fi
OnBalance	http://www.quartzstar.com/
PlanEval	http://heureka.resgeom.slu.se/wiki/index.php?title=PlanEval
Promax	http://www.cogentus.co.uk/products/
PUrE2	http://www.pureintrawise.org/
TESLA	http://www.quintessa.org/software/tesla.html
The Decision Deck project	http://www.decision-deck.org
V.I.P. Analysis	http://www.uc.pt/en/feuc/ldias/software/vipa
V.I.S.A. Decisions	http://www.visadecisions.com/
Web-HIPRE	http://www.hipre.hut.fi
WINPRE	http://sal.aalto.fi/en/resources/downloadables/winpre

Appendix B. Screenshots of the software

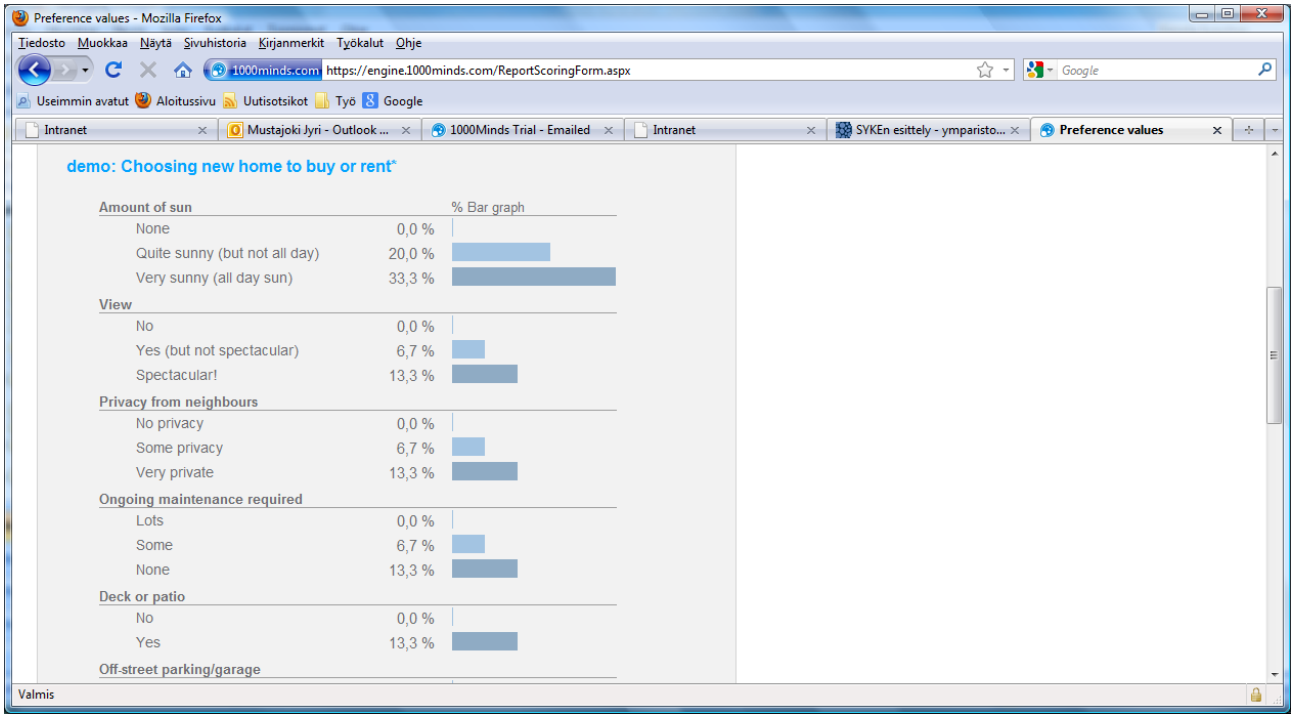
1000Minds



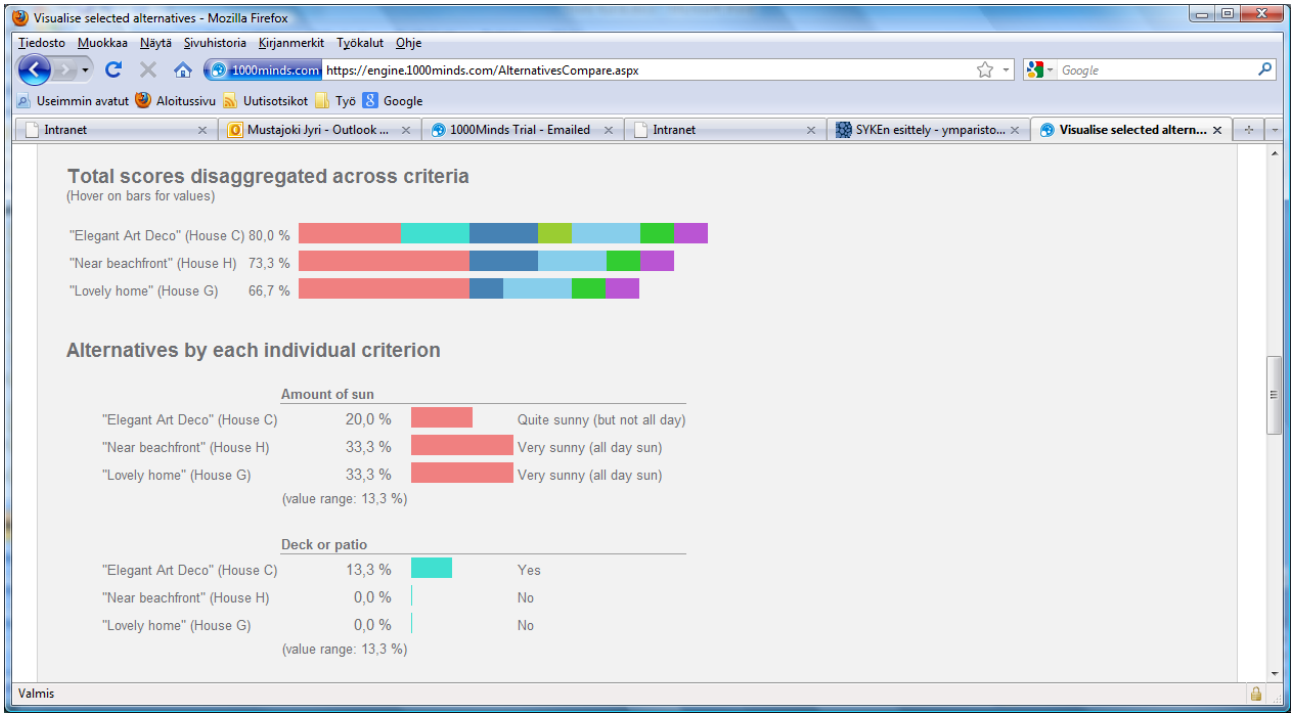
Consequences table



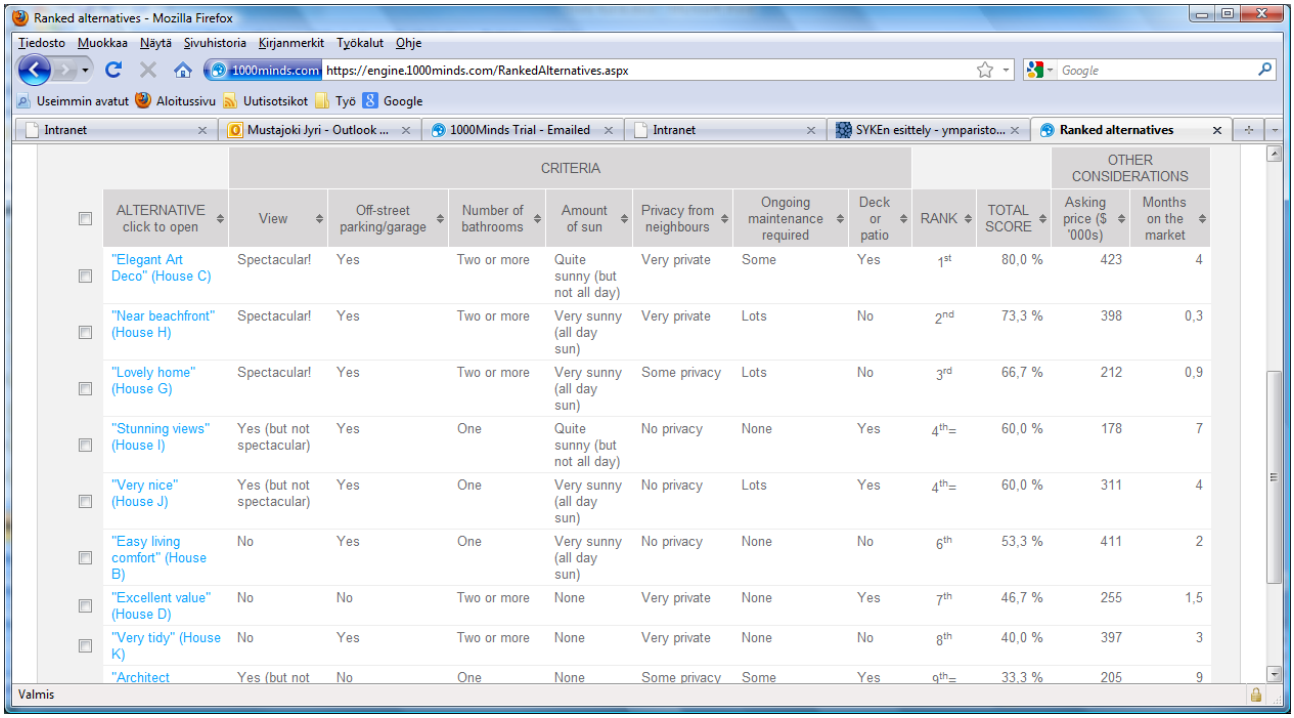
Trade-offs



Preferences

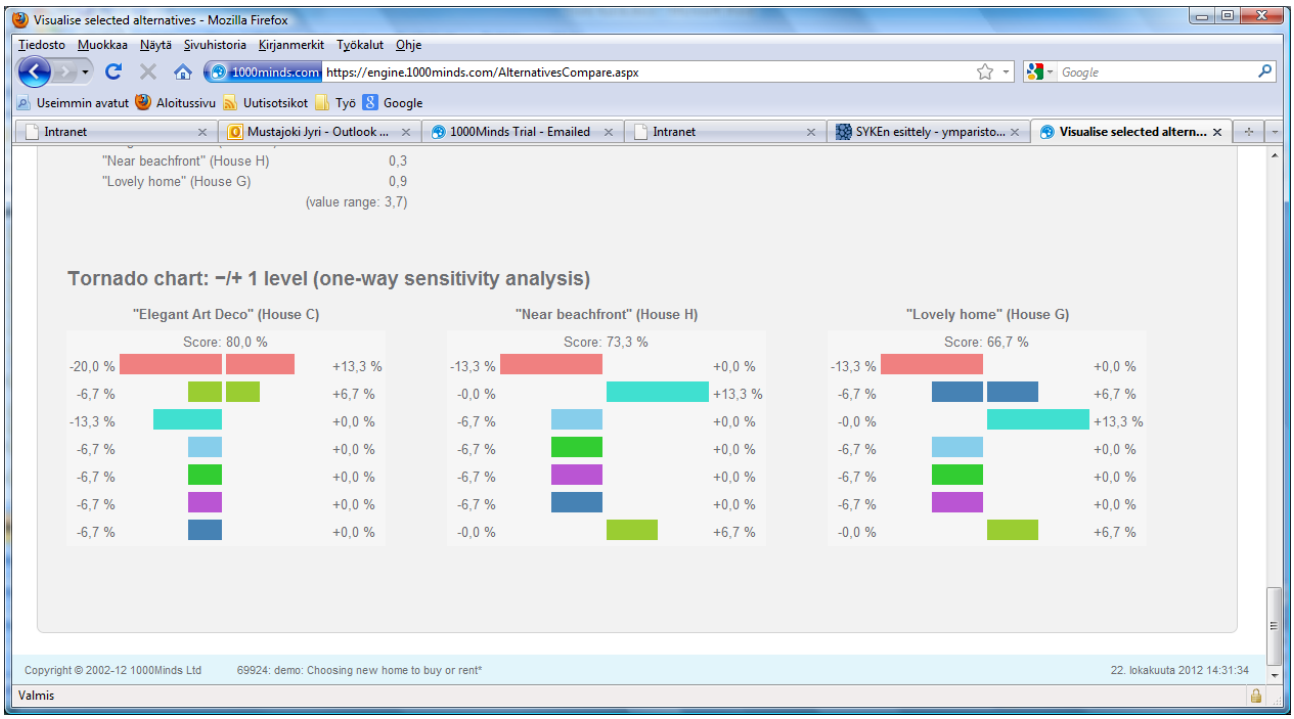


Overall values



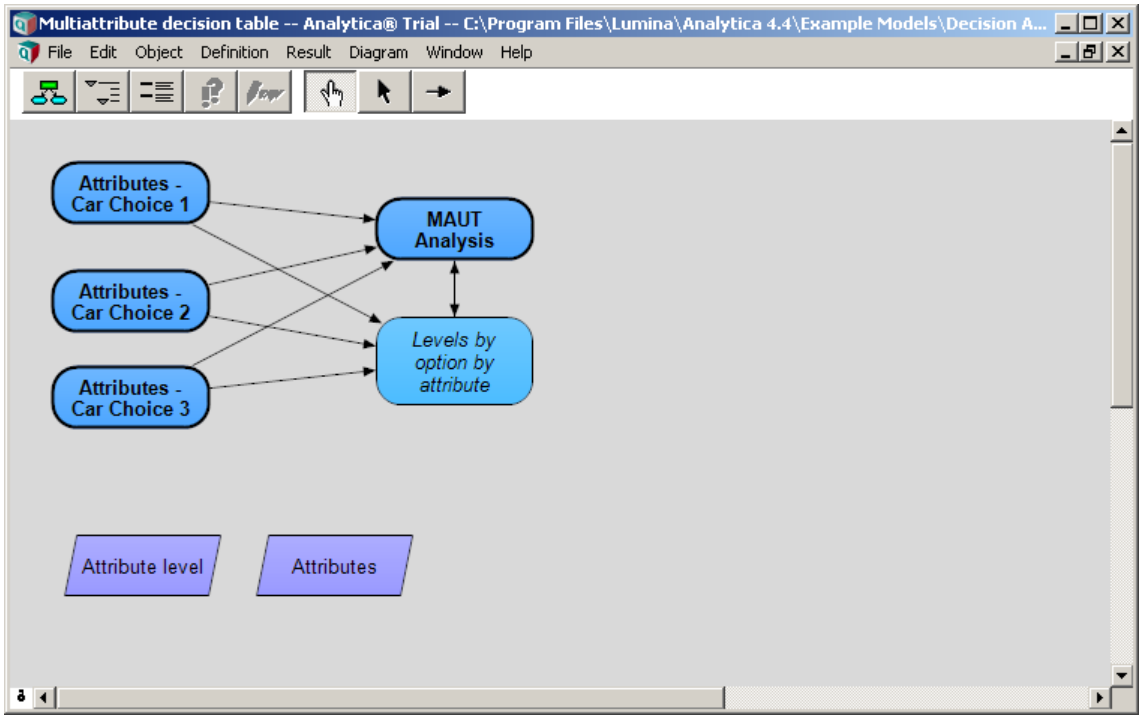
	ALTERNATIVE click to open	CRITERIA: View	Off-street parking/garage	Number of bathrooms	Amount of sun	Privacy from neighbours	Ongoing maintenance required	Deck or patio	RANK	TOTAL SCORE	OTHER CONSIDERATIONS: Asking price ($ '000s)	Months on the market
	"Elegant Art Deco" (House C)	Spectacular!	Yes	Two or more	Quite sunny (but not all day)	Very private	Some	Yes	1st	80,0 %	423	4
	"Near beachfront" (House H)	Spectacular!	Yes	Two or more	Very sunny (all day sun)	Very private	Lots	No	2nd	73,3 %	398	0,3
	"Lovely home" (House G)	Spectacular!	Yes	Two or more	Very sunny (all day sun)	Some privacy	Lots	No	3rd	66,7 %	212	0,9
	"Stunning views" (House I)	Yes (but not spectacular)	Yes	One	Quite sunny (but not all day)	No privacy	None	Yes	4th=	60,0 %	178	7
	"Very nice" (House J)	Yes (but not spectacular)	Yes	One	Very sunny (all day sun)	No privacy	Lots	Yes	4th=	60,0 %	311	4
	"Easy living comfort" (House B)	No	Yes	One	Very sunny (all day sun)	No privacy	None	No	6th	53,3 %	411	2
	"Excellent value" (House D)	No	No	Two or more	None	Very private	None	Yes	7th	46,7 %	255	1,5
	"Very tidy" (House K)	No	Yes	Two or more	None	Very private	None	No	8th	40,0 %	397	3
	"Architect	Yes (but not	No	One	None	Some privacy	Some	Yes	9th=	33,3 %	205	9

Ranking of the alternatives

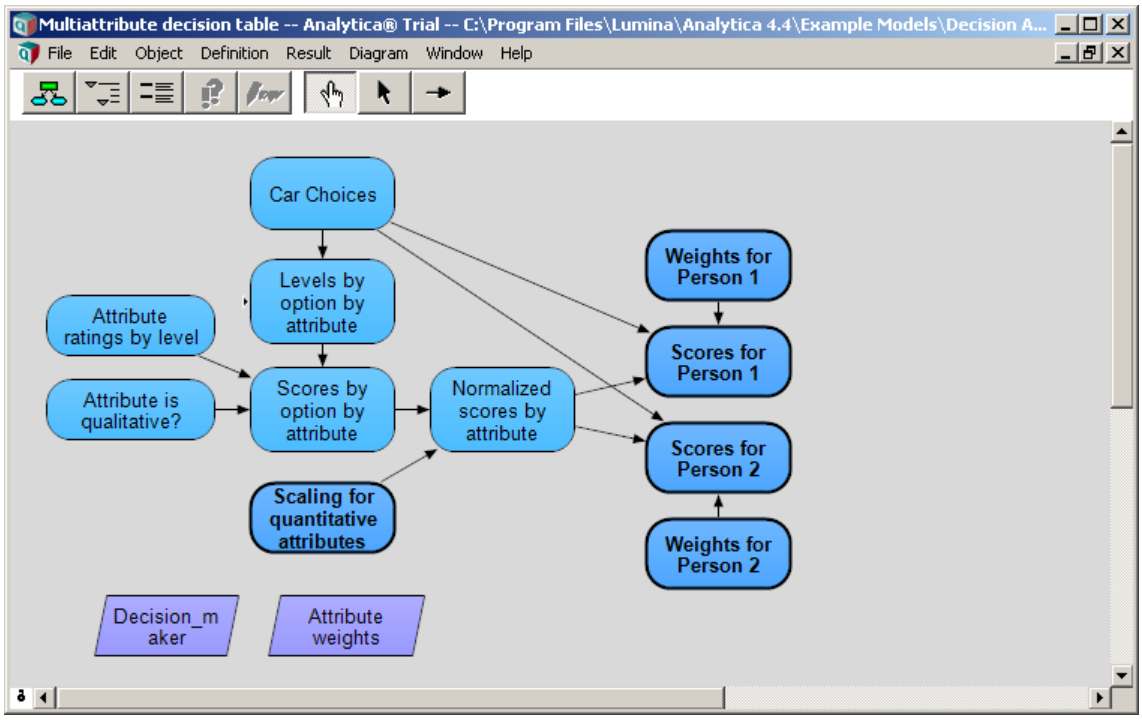


Sensitivity analysis

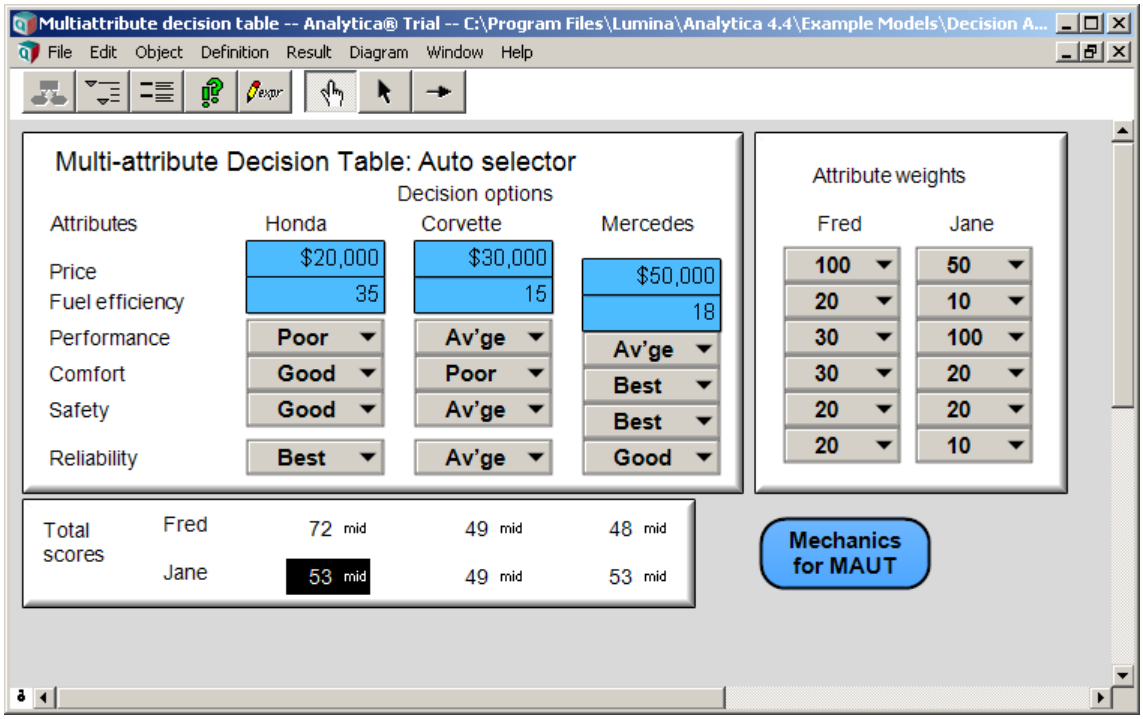
Analytica



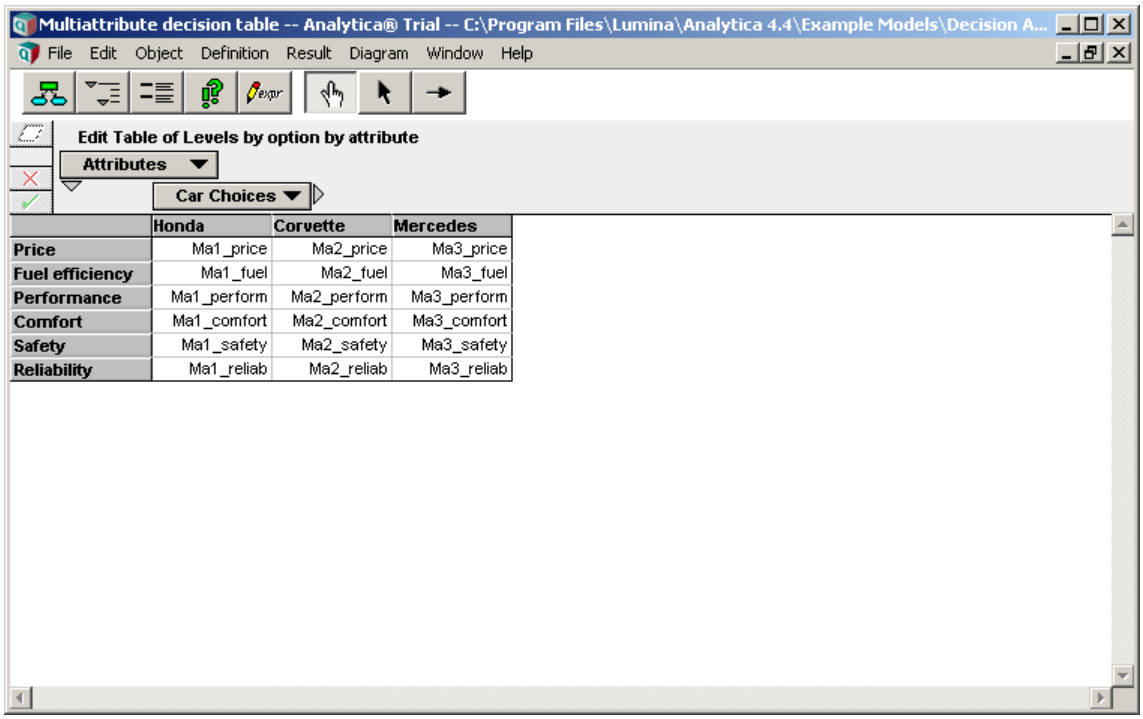
Influence diagram



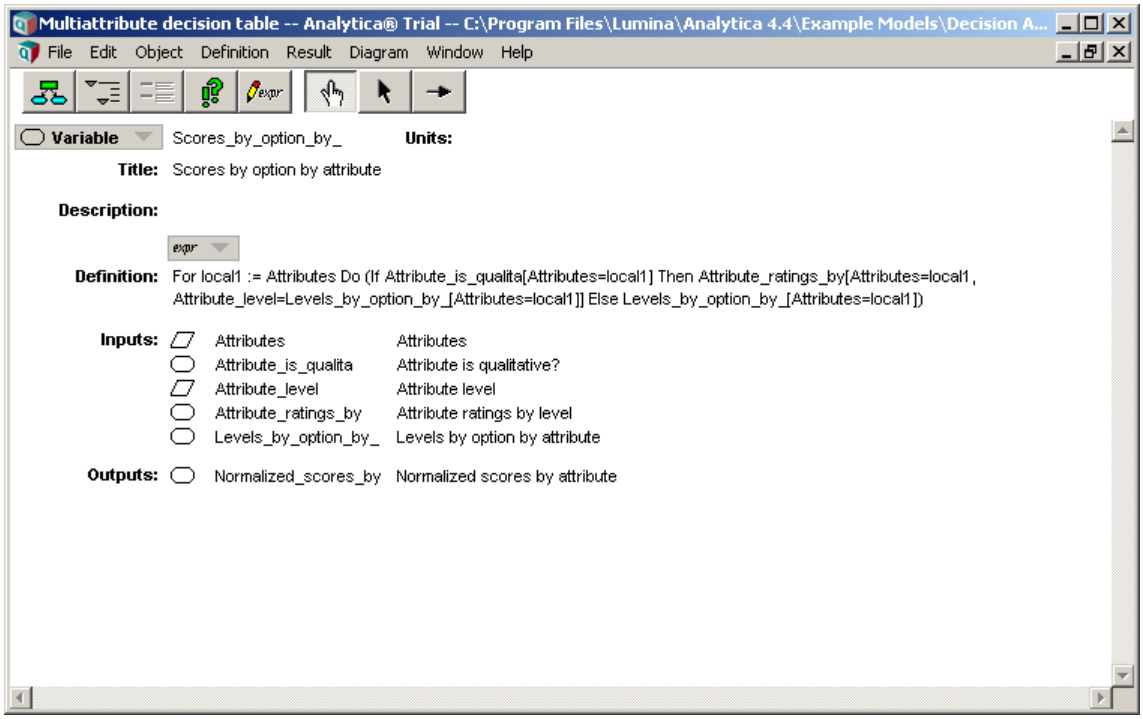
Influence diagram



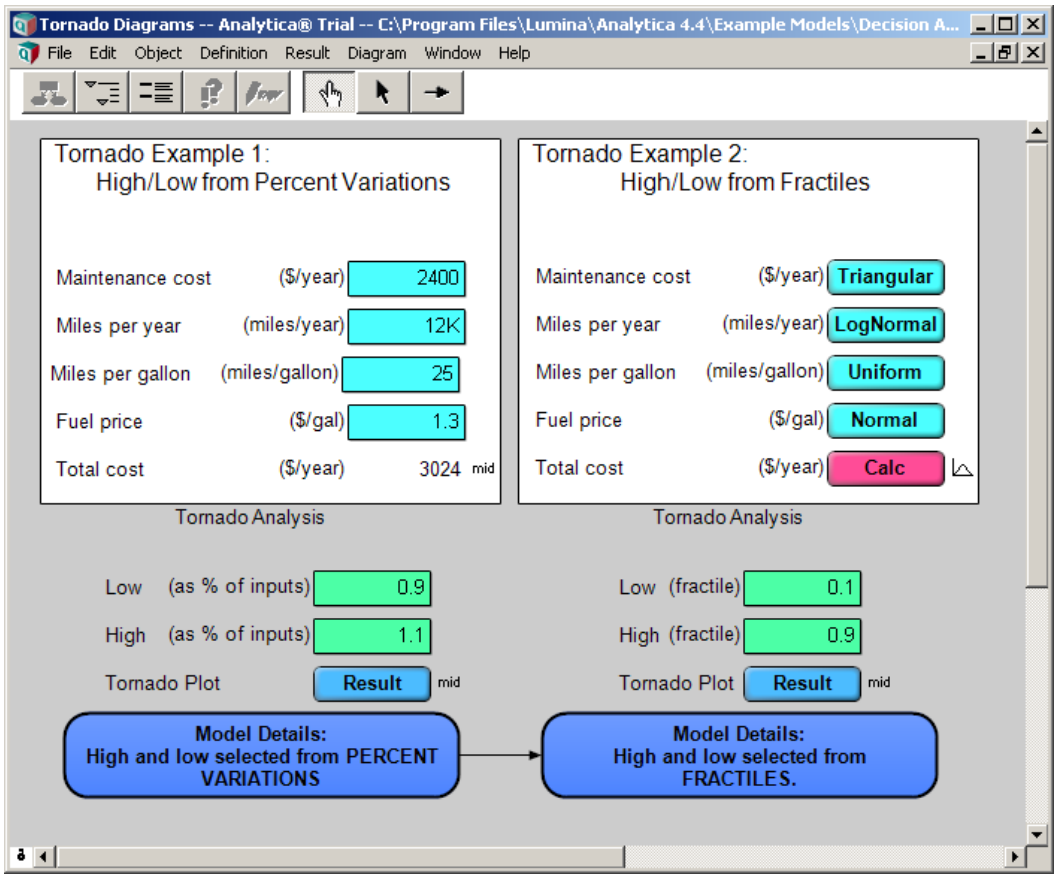
Decision table



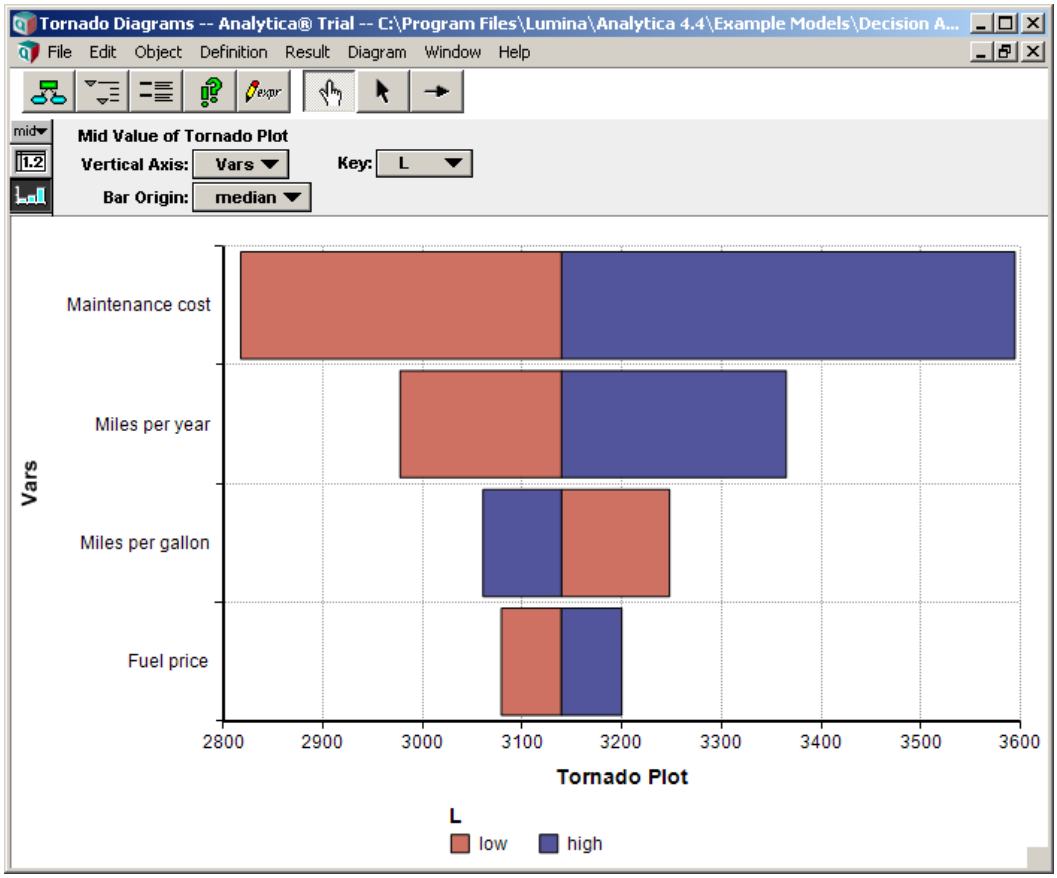
Performance matrix



Unit definitions

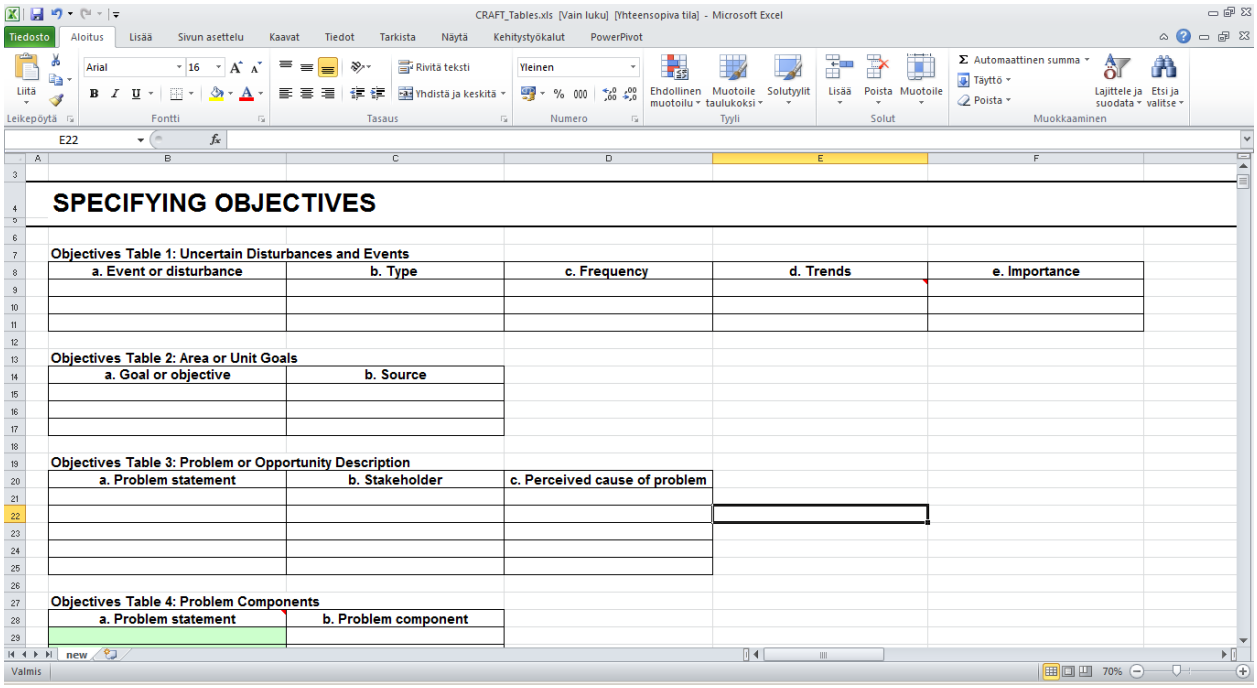


Tornado analysis - settings



Tornado diagram

CRAFT



SPECIFYING OBJECTIVES

Objectives Table 1: Uncertain Disturbances and Events

a. Event or disturbance	b. Type	c. Frequency	d. Trends	e. Importance

Objectives Table 2: Area or Unit Goals

a. Goal or objective	b. Source

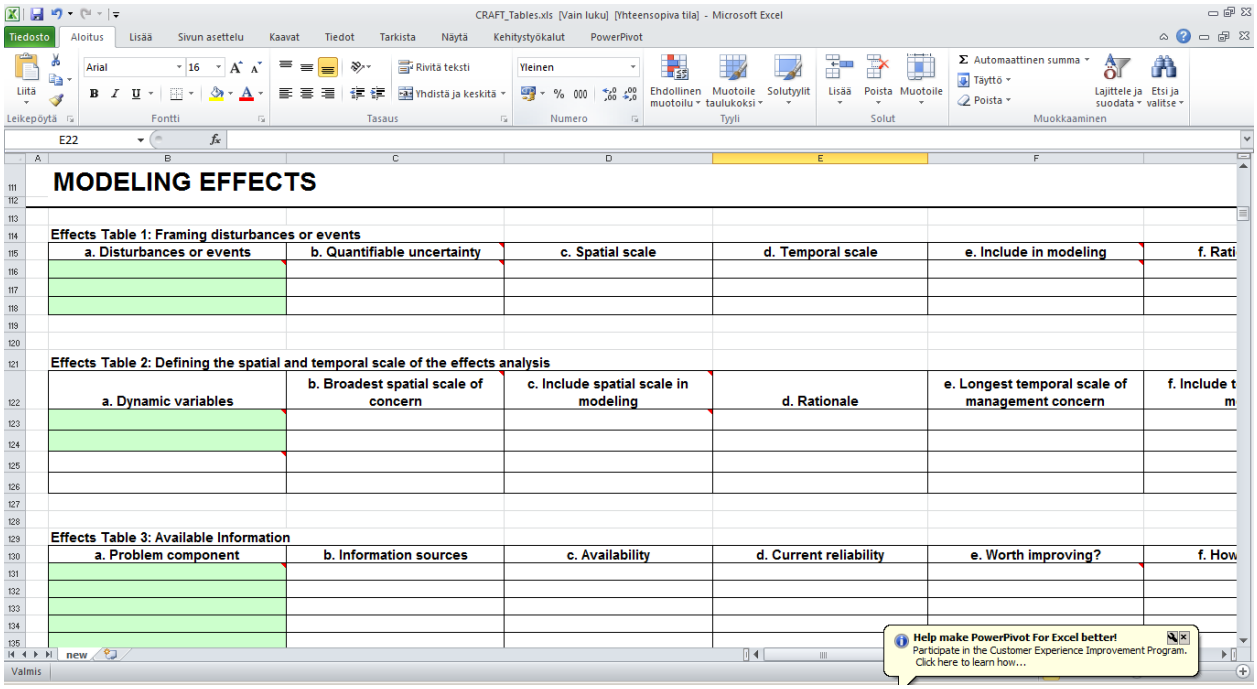
Objectives Table 3: Problem or Opportunity Description

a. Problem statement	b. Stakeholder	c. Perceived cause of problem

Objectives Table 4: Problem Components

a. Problem statement	b. Problem component

Objectives table



MODELING EFFECTS

Effects Table 1: Framing disturbances or events

a. Disturbances or events	b. Quantifiable uncertainty	c. Spatial scale	d. Temporal scale	e. Include in modeling	f. Rati

Effects Table 2: Defining the spatial and temporal scale of the effects analysis

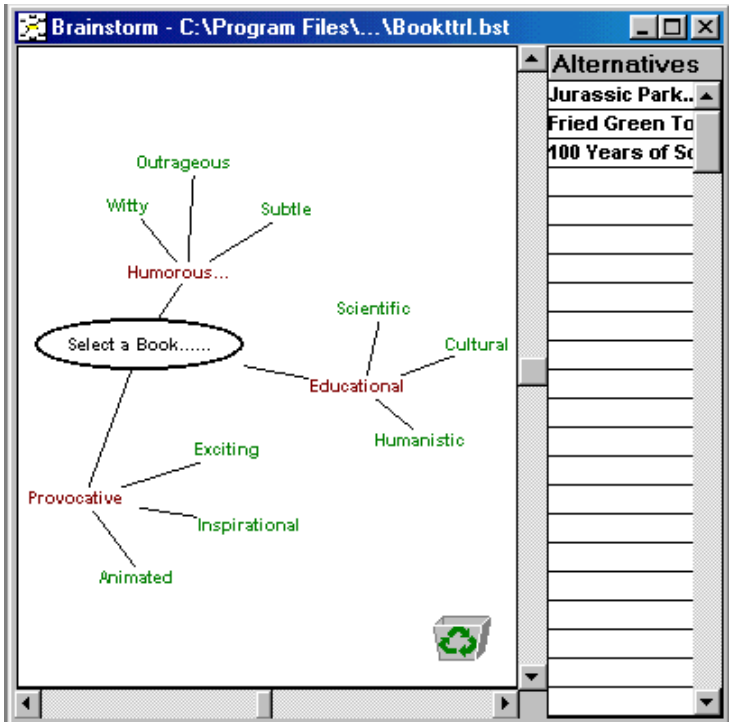
a. Dynamic variables	b. Broadest spatial scale of concern	c. Include spatial scale in modeling	d. Rationale	e. Longest temporal scale of management concern	f. Include t m

Effects Table 3: Available Information

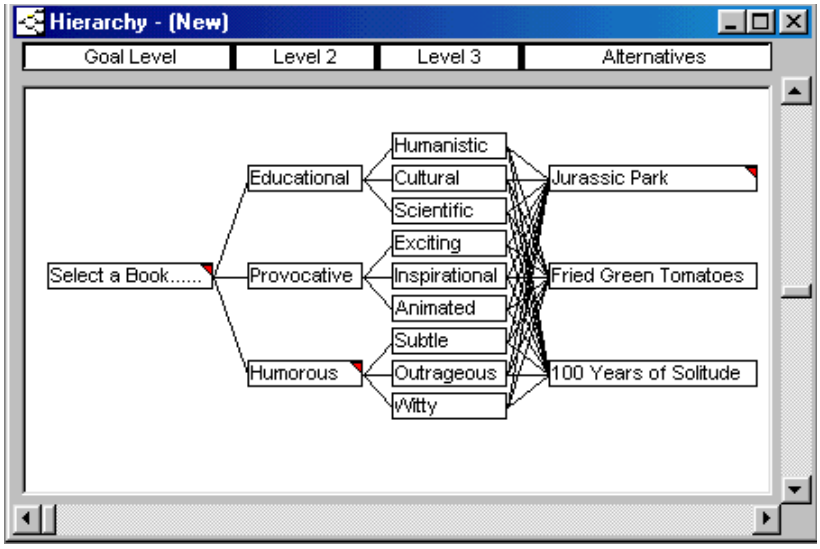
a. Problem component	b. Information sources	c. Availability	d. Current reliability	e. Worth improving?	f. How

Effects table

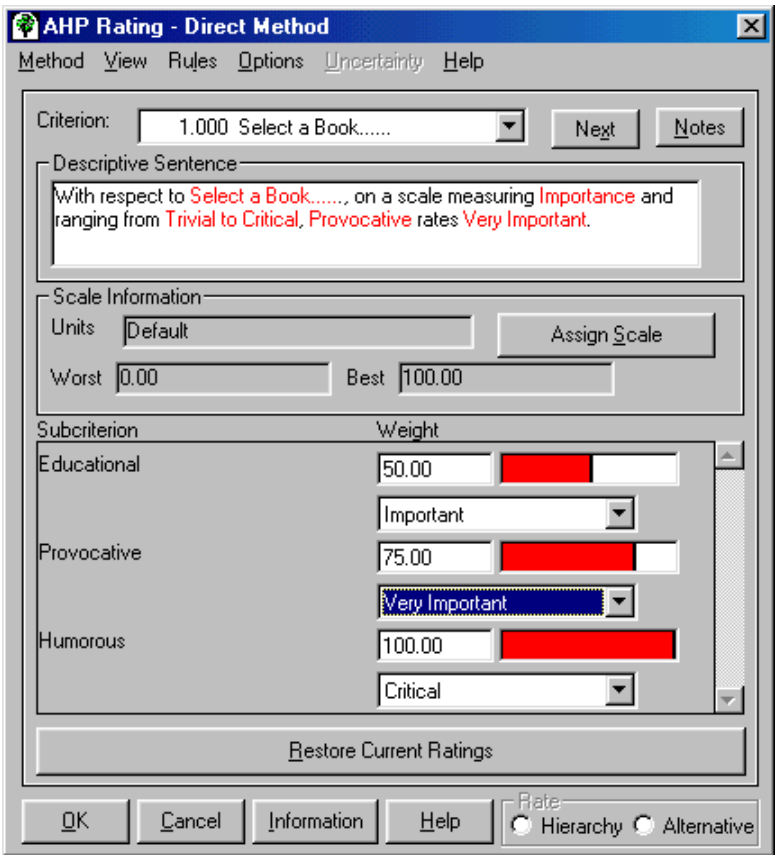
Criterium Decision Plus



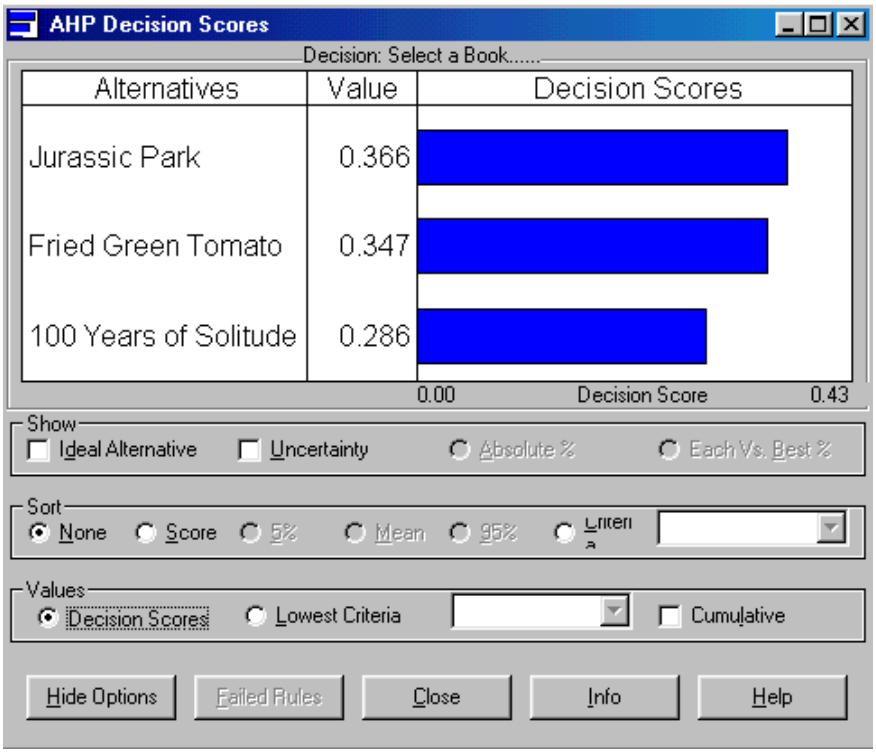
Brainstorming



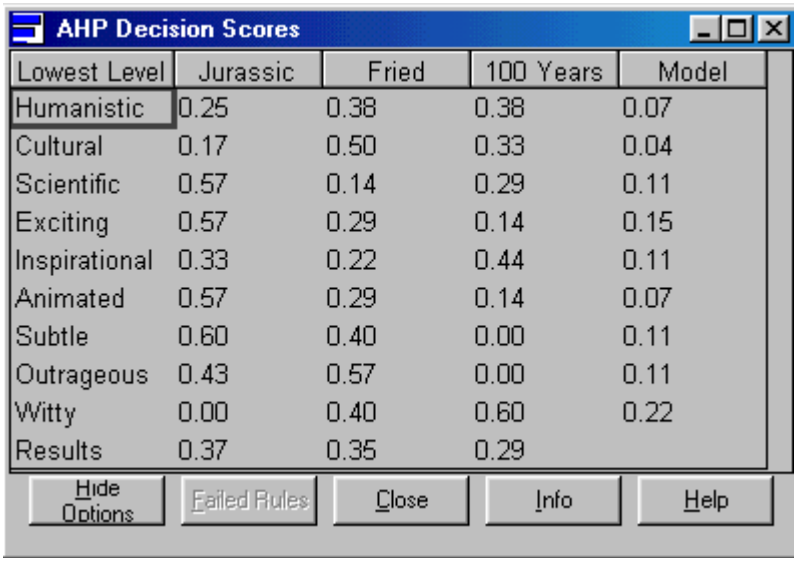
Hierarchy



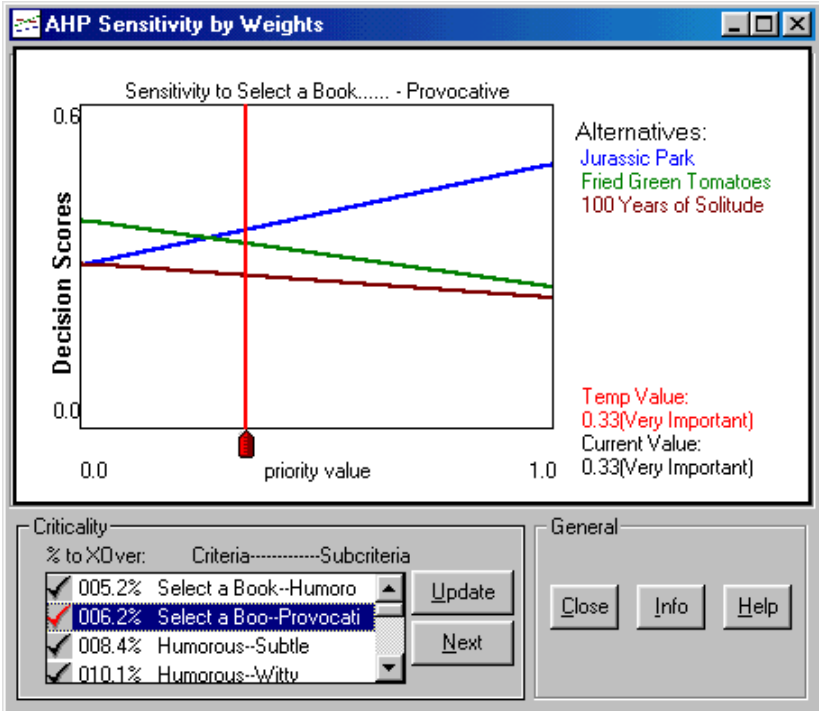
AHP-rating



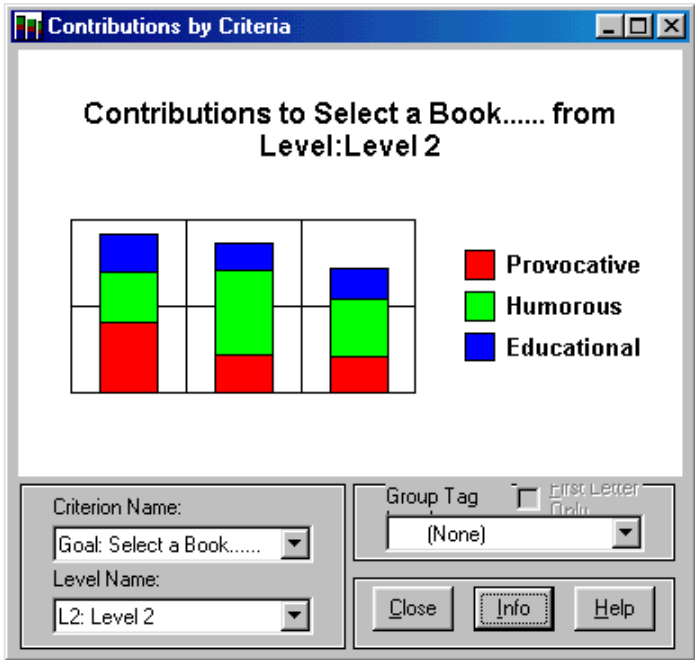
Scores



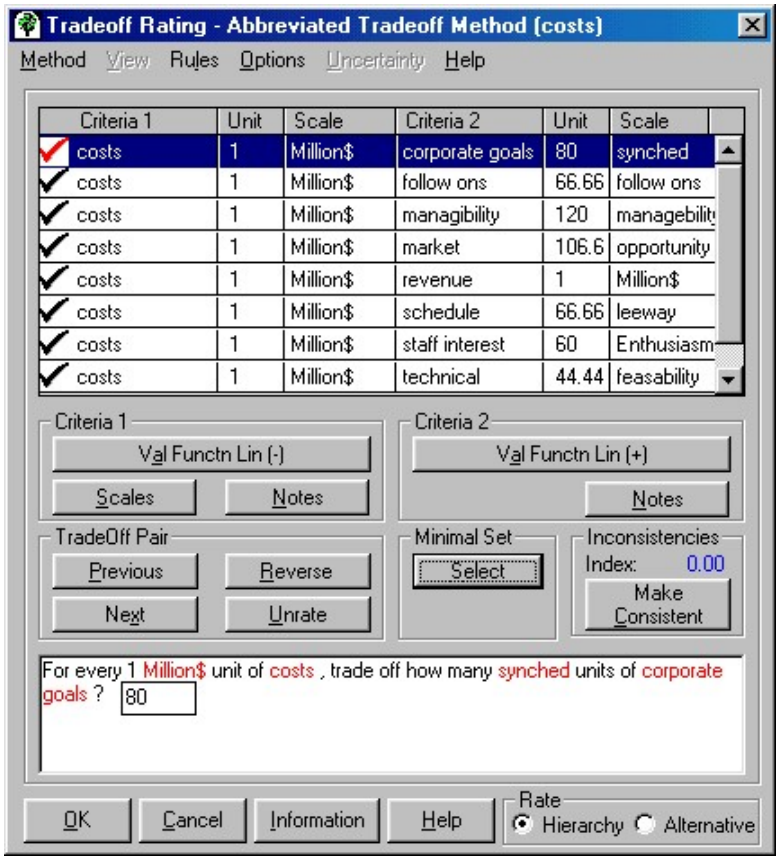
Scores



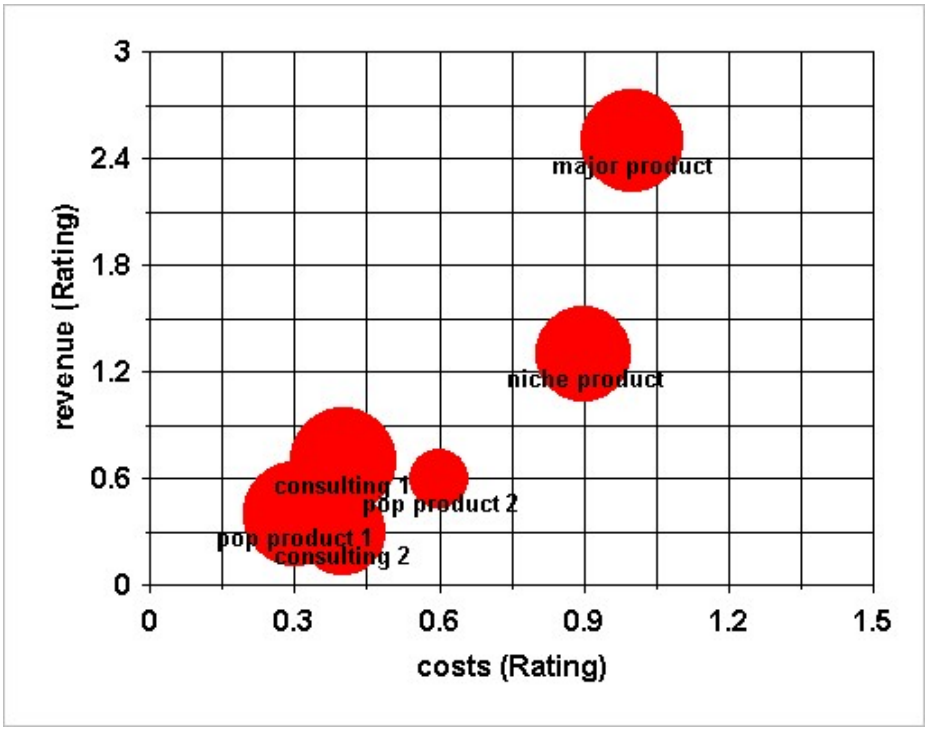
Sensitivity analysis



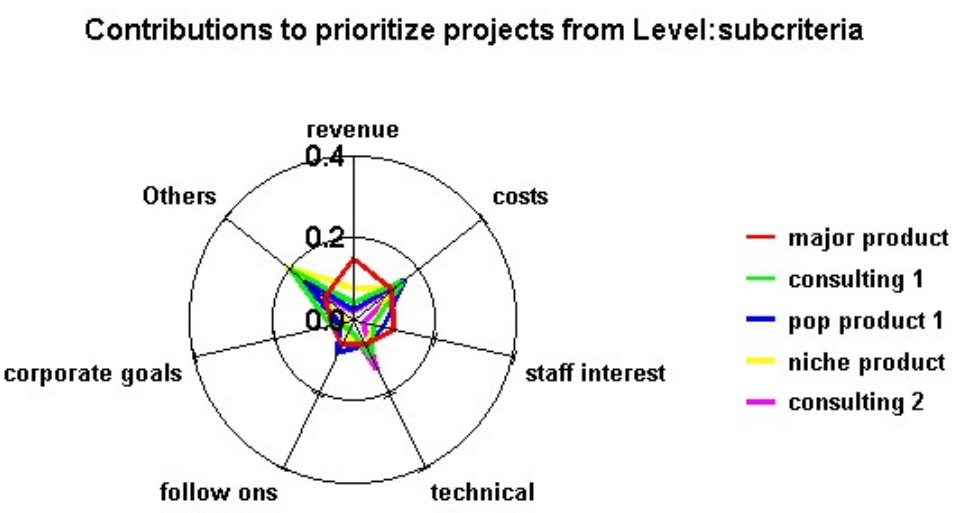
Criteria contributions



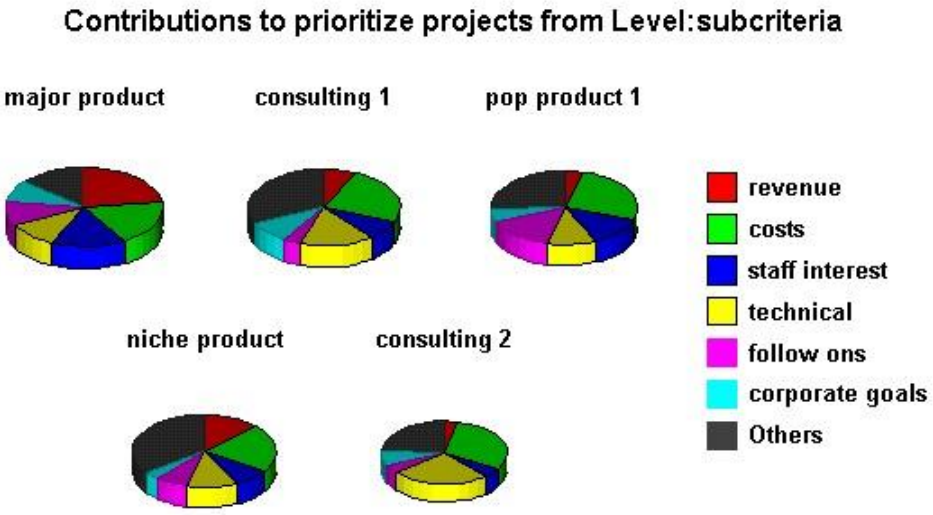
Trade-off rating



Scatter plot

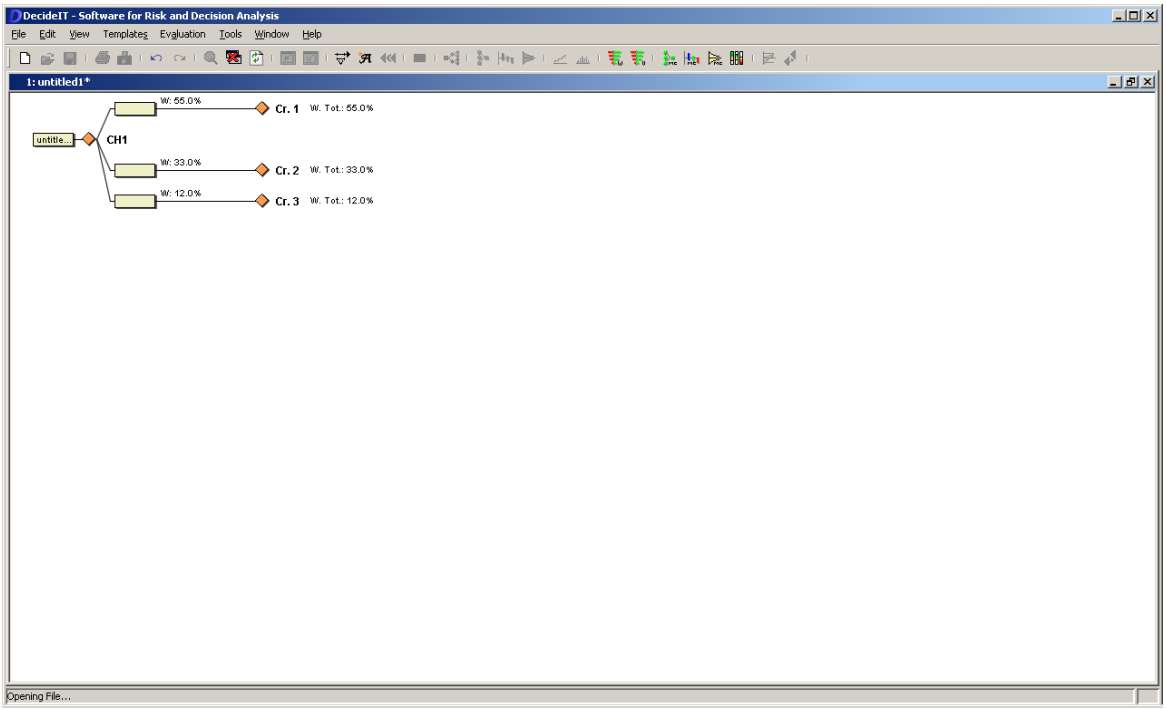


Spider graph

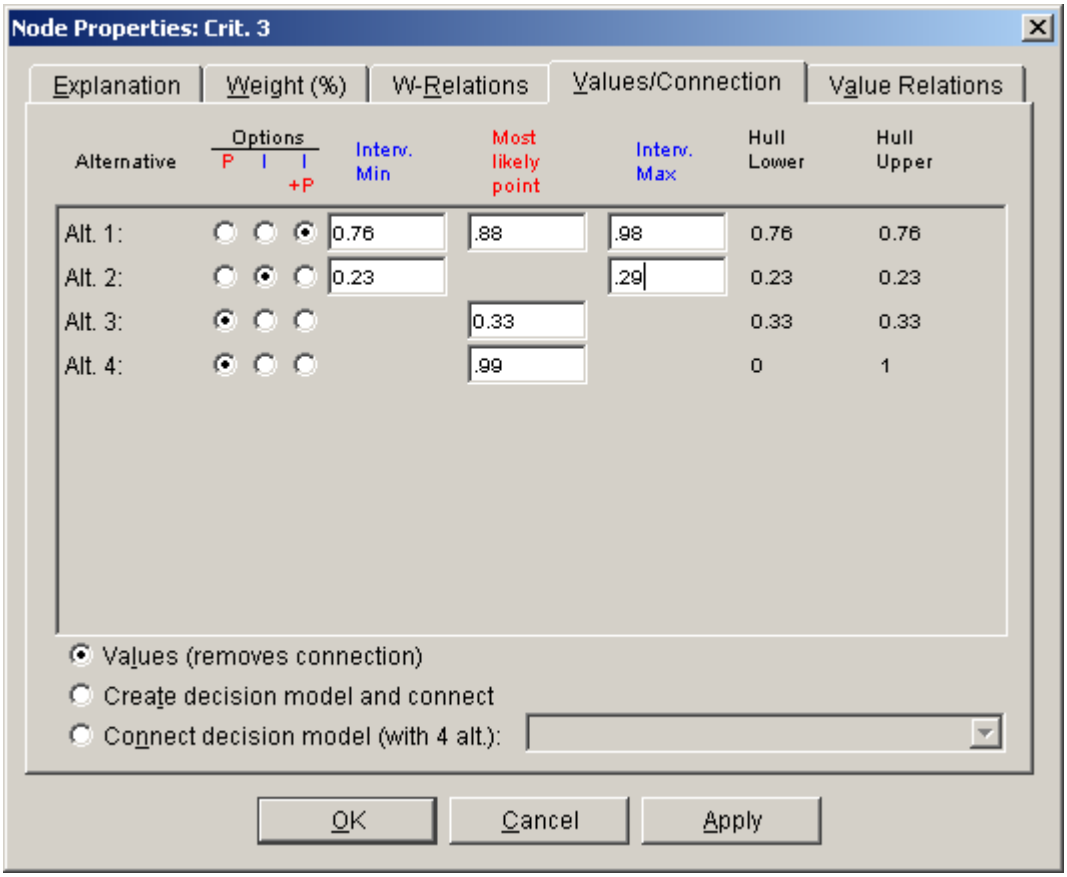


Criteria contributions

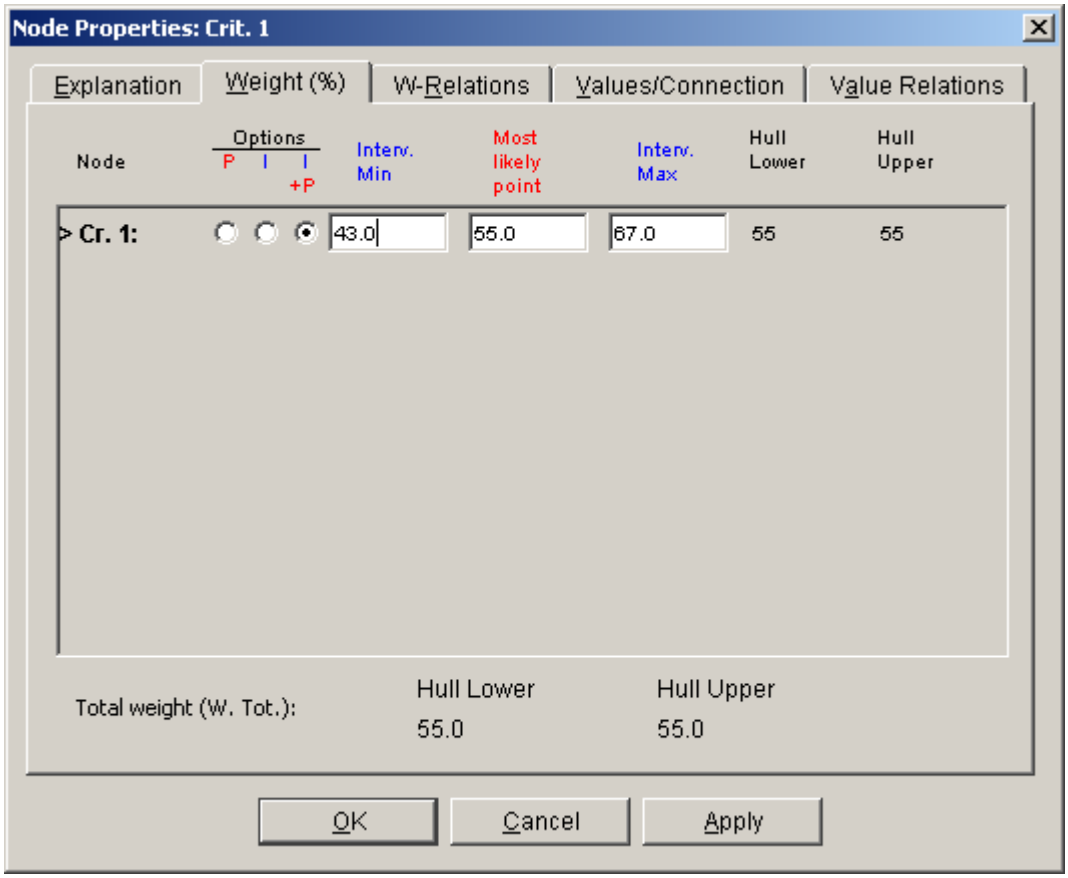
DecideIT



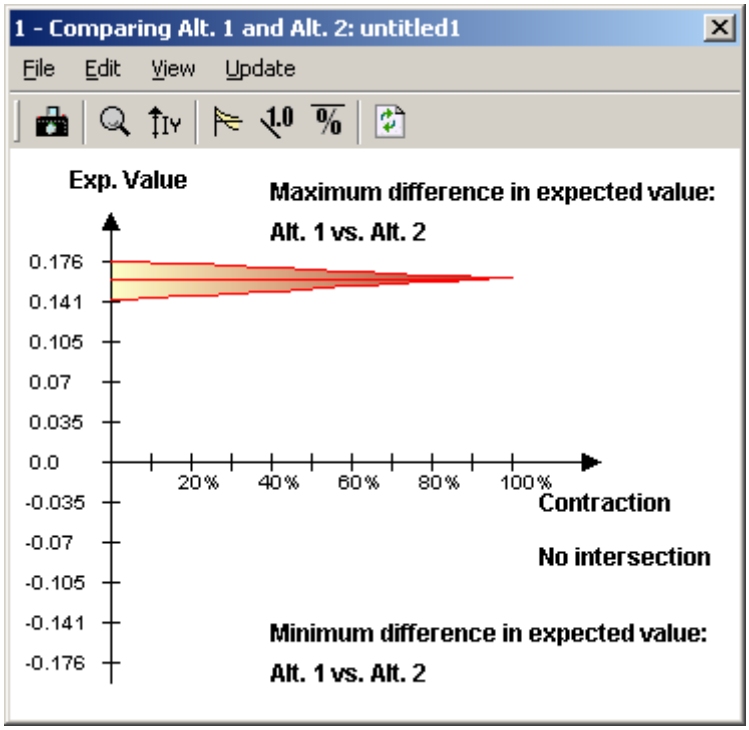
Value tree



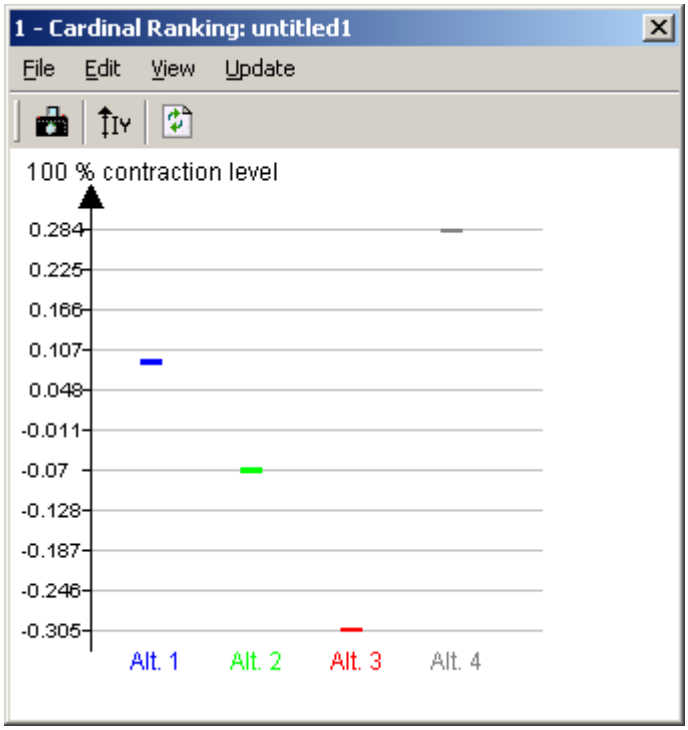
Setting of values



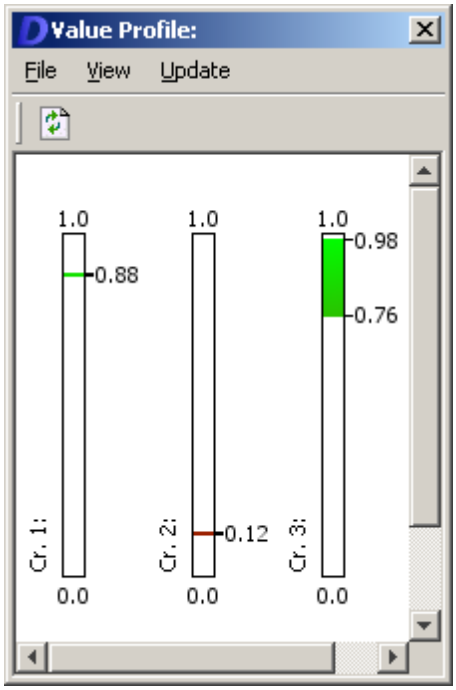
Setting of the weights



Pairwise comparison of the alternatives

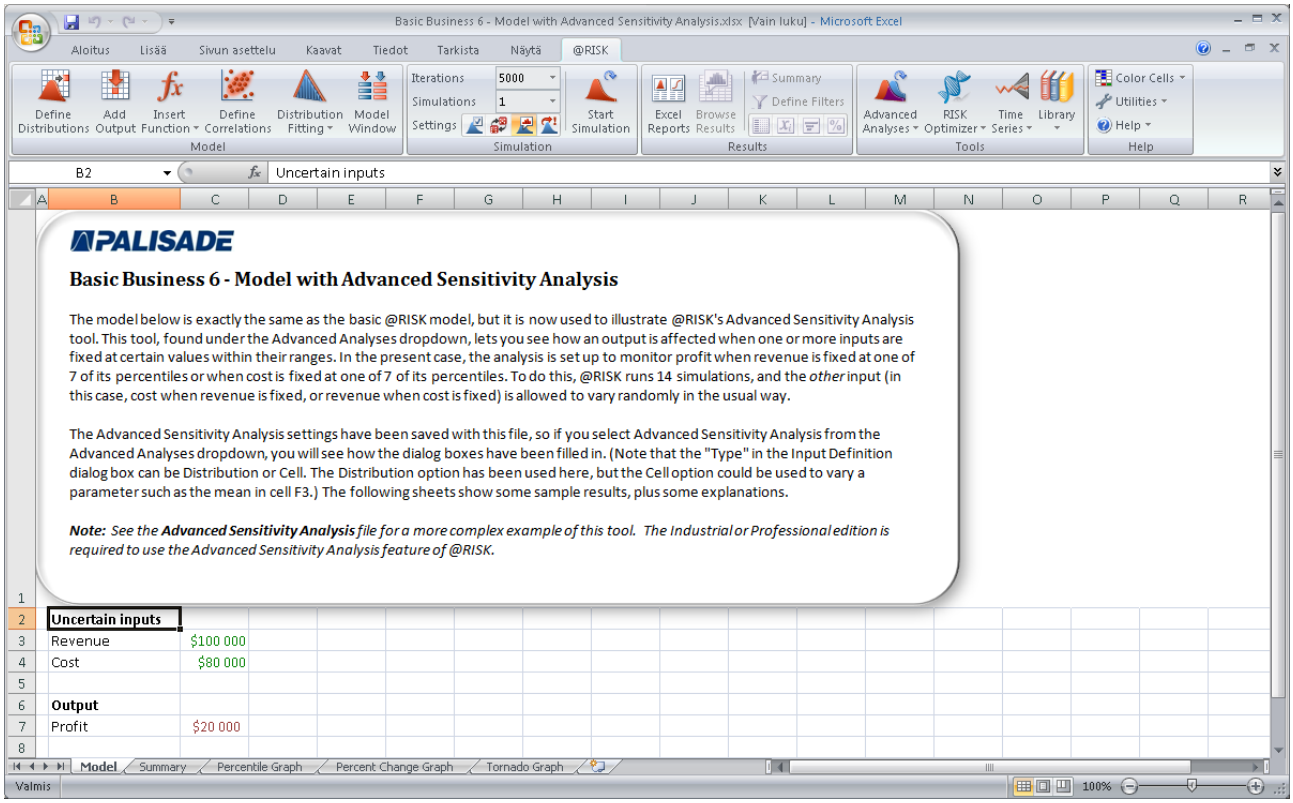


Cardinal rankings

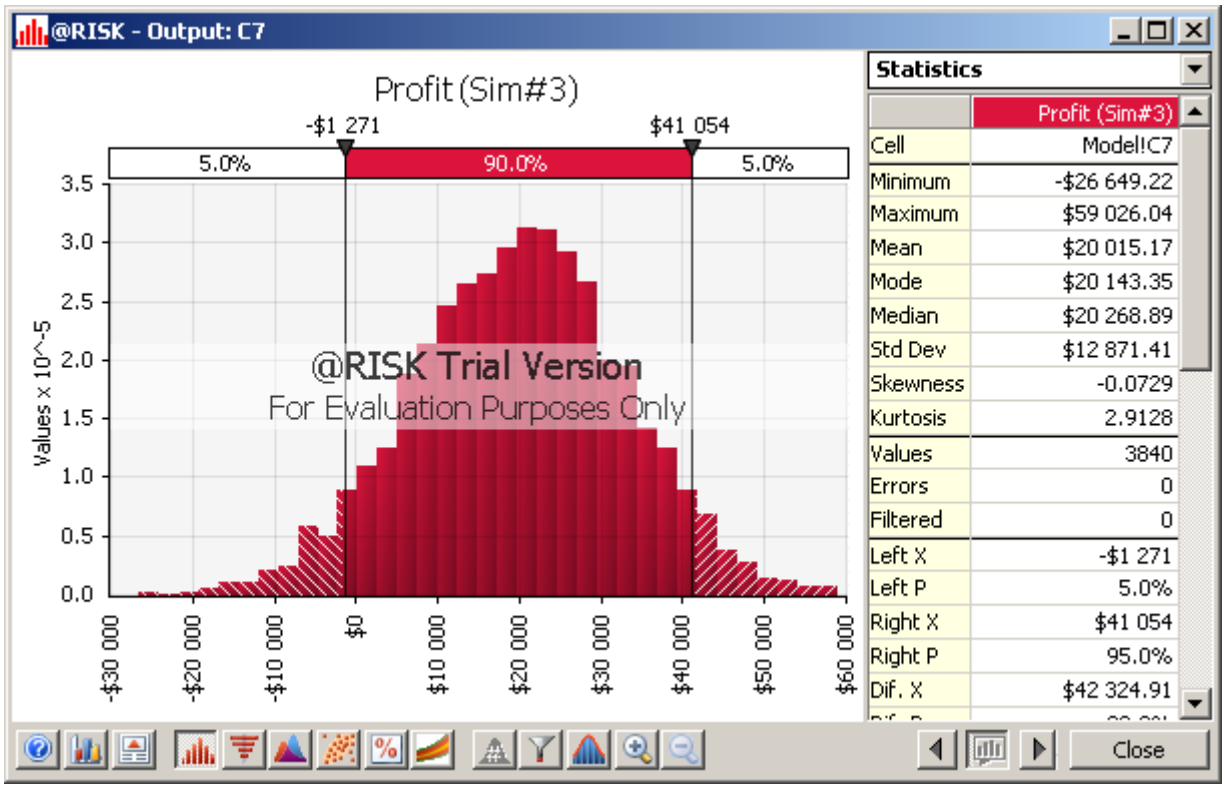


Value profile

Decision Tools – @RISK

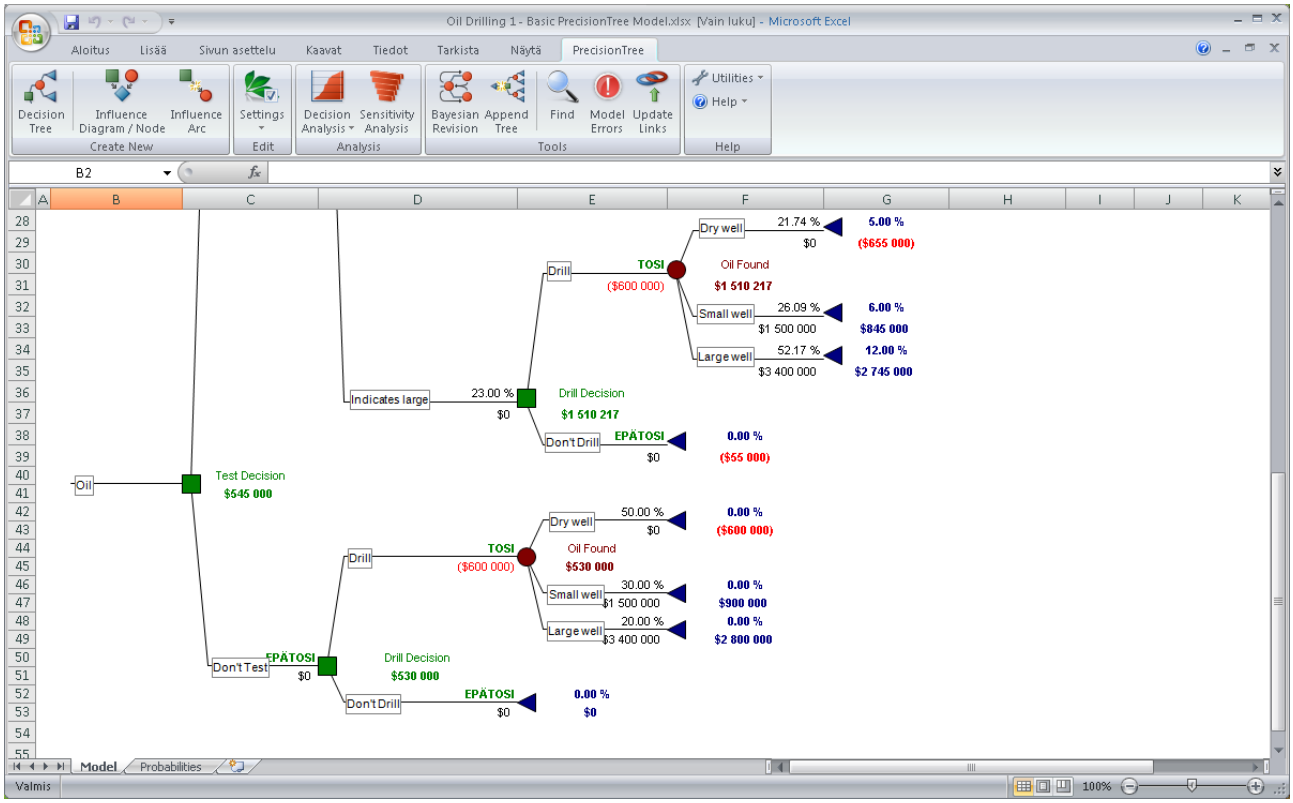


Tools window with a simple example.

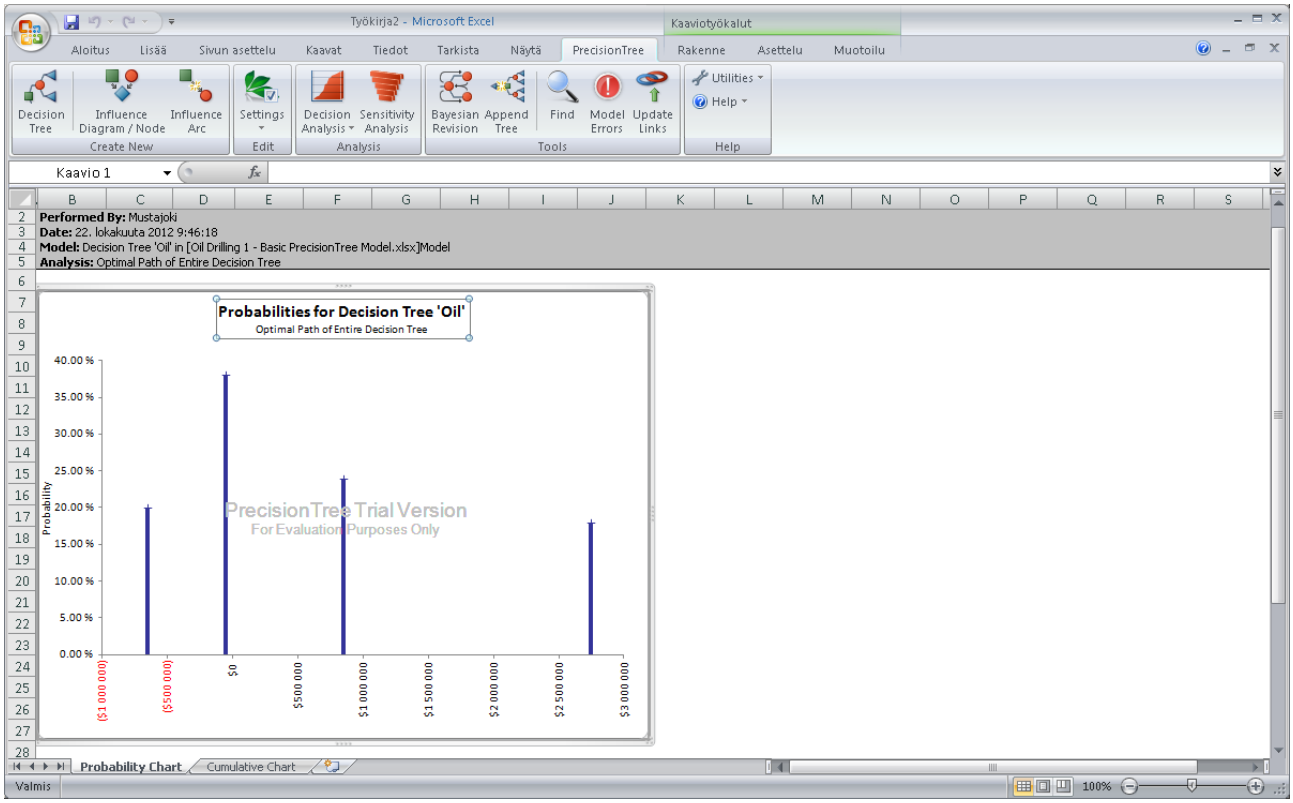


Simulation output example

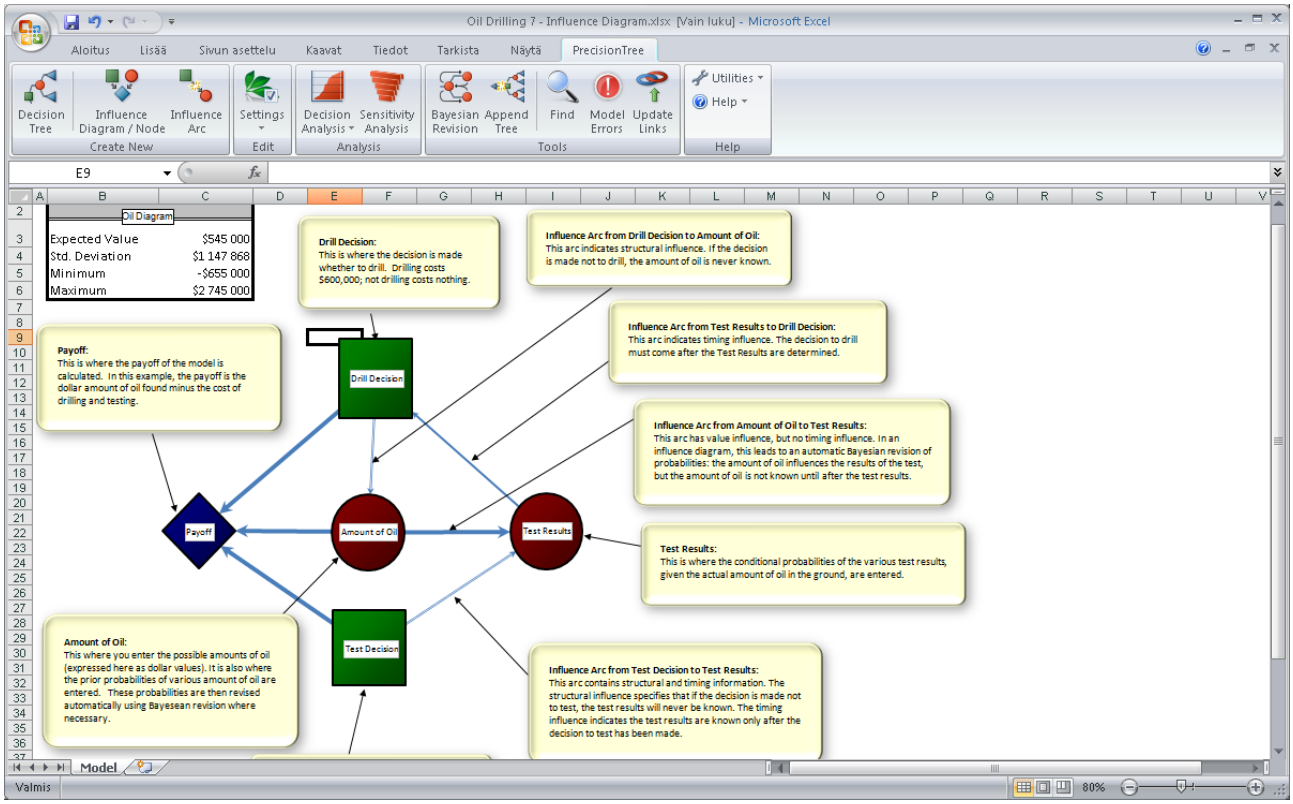
Decision Tools – Precision tree



Decision tree with an oil drilling example

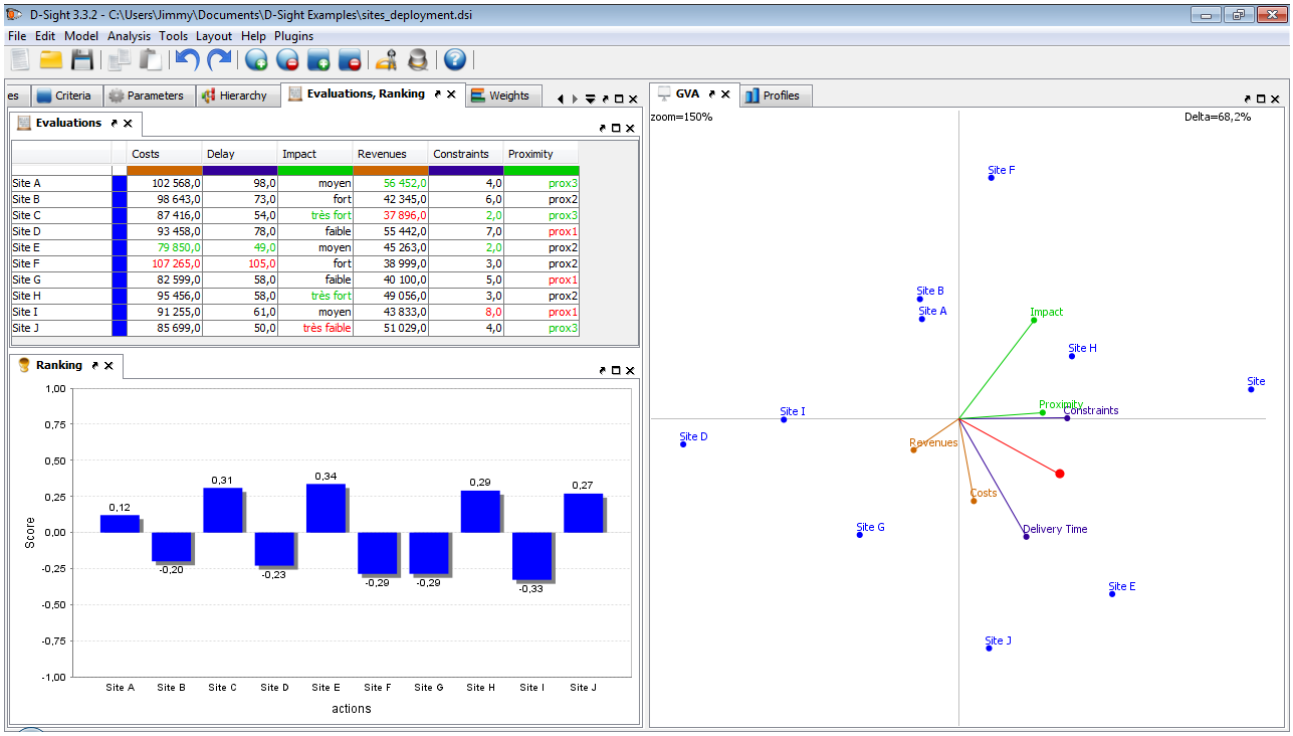


Probability chart

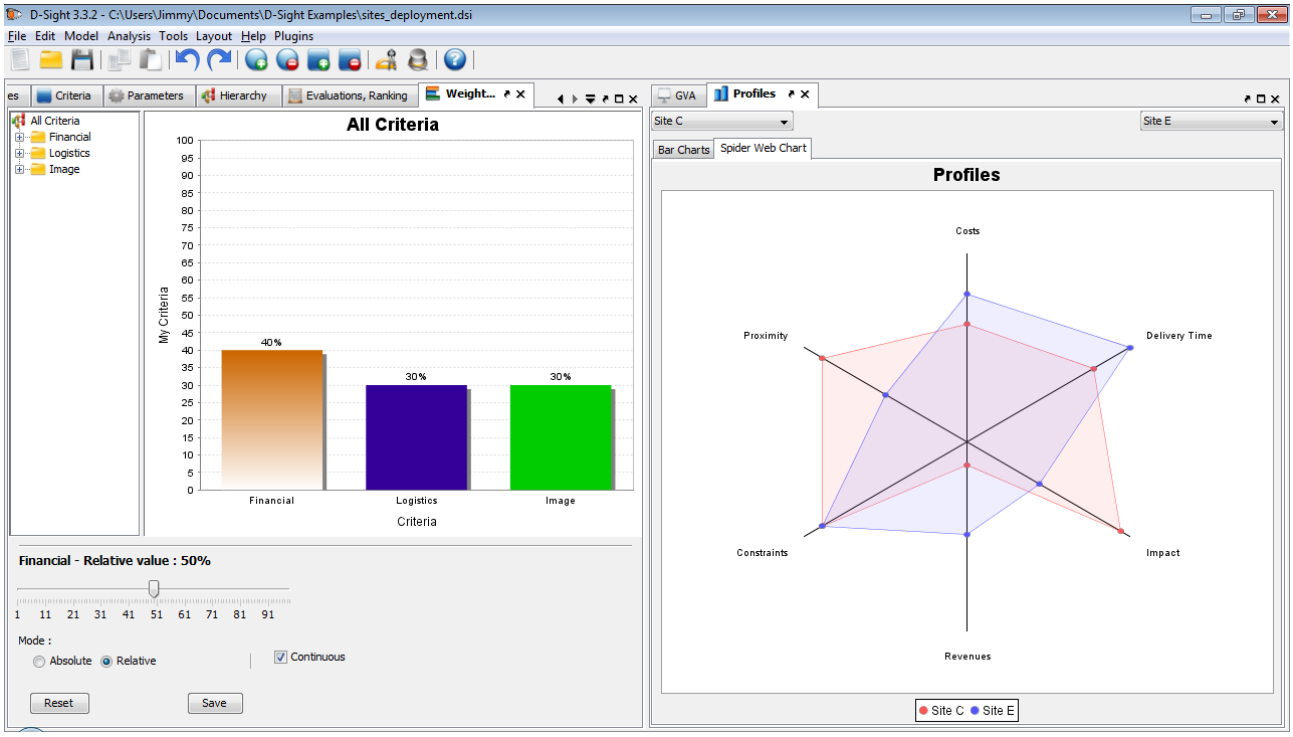


Influence diagram

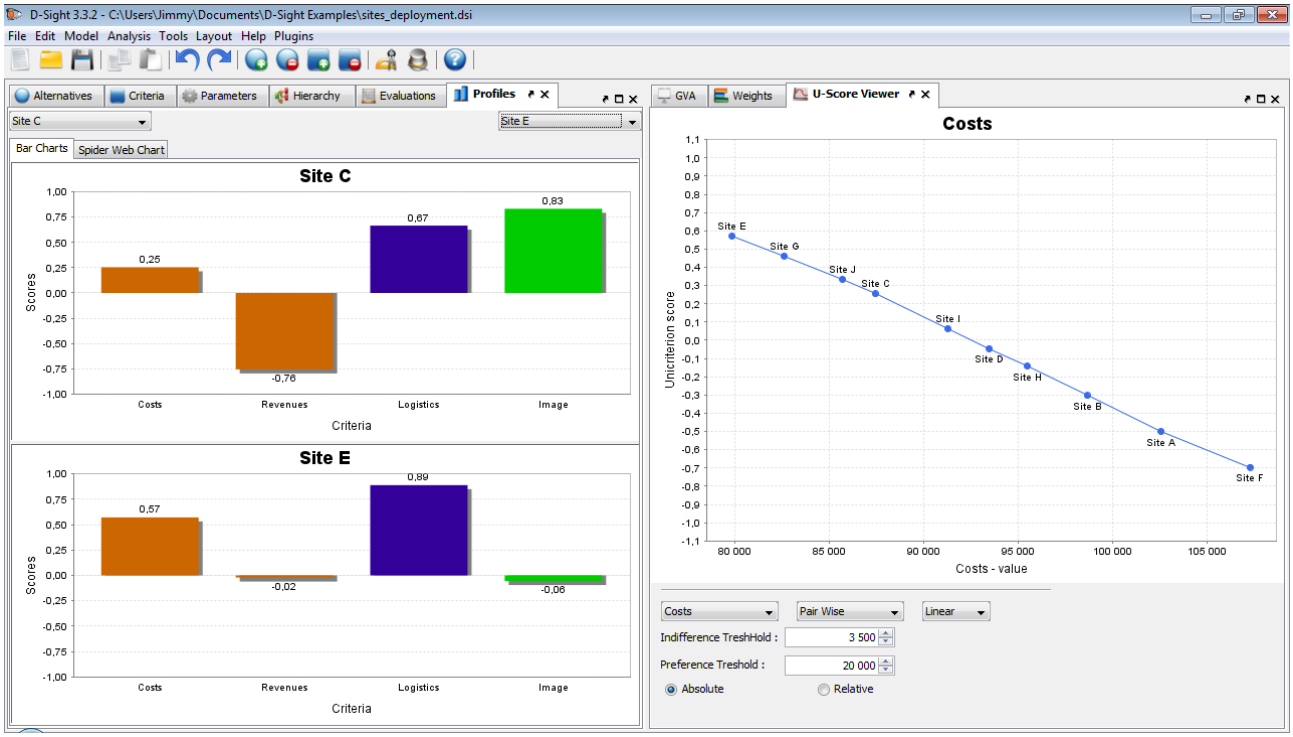
D-Sight



Consequences table and the ranking of the alternatives

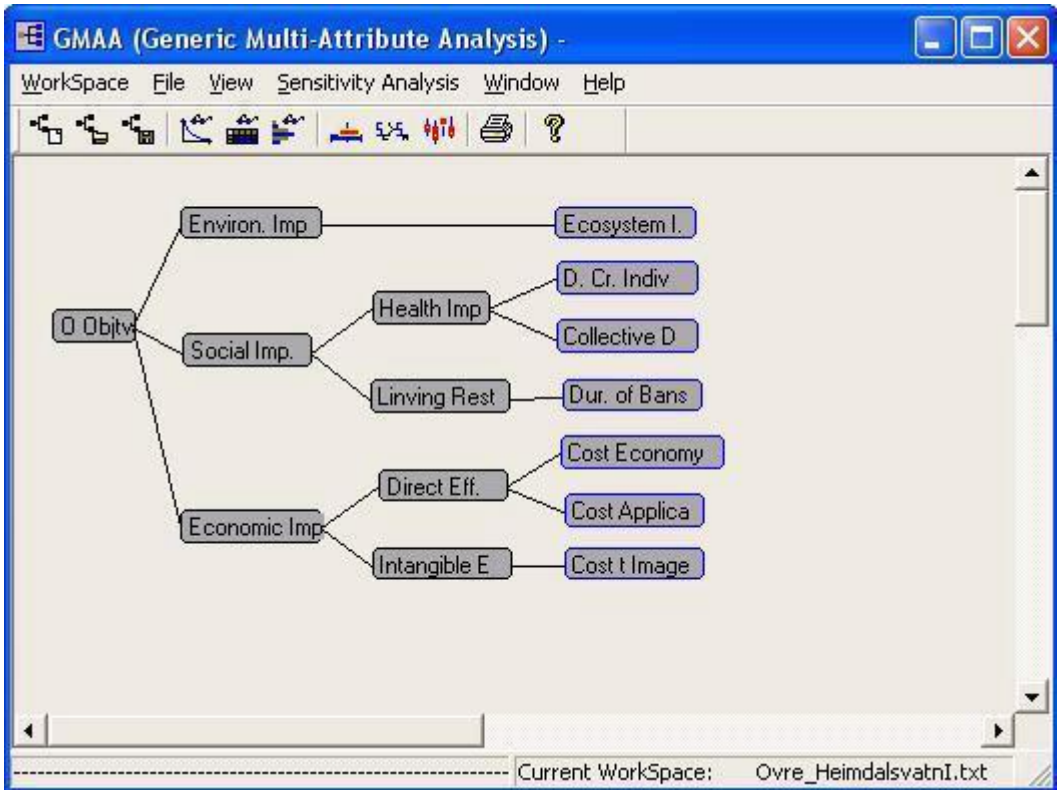


Criteria weights and spider graph



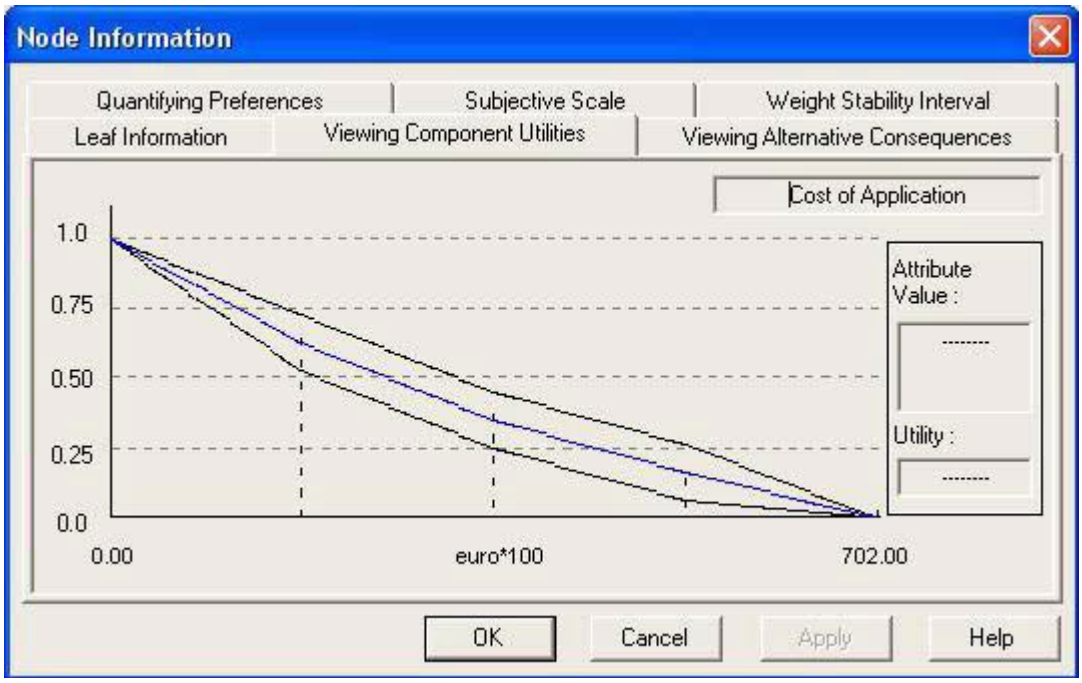
Bar charts and score vs. cost -graph

GMAA

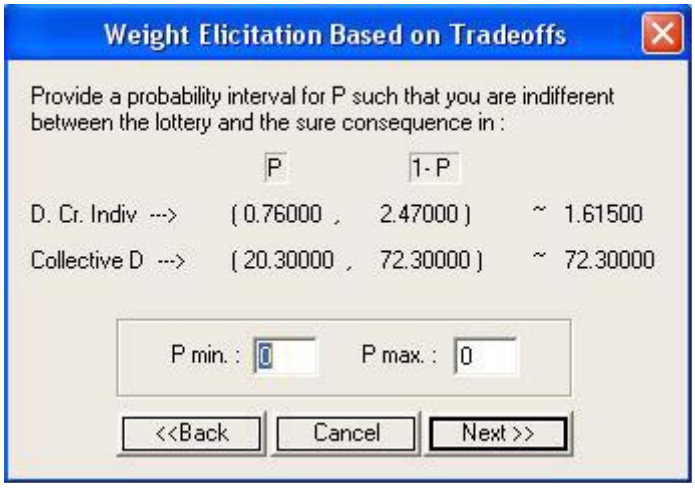


Value tree

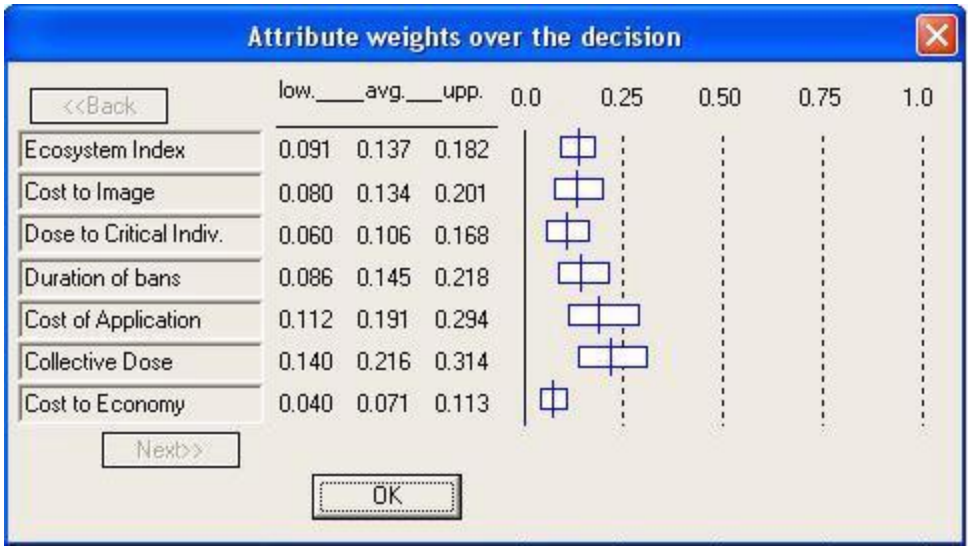
Consequences table



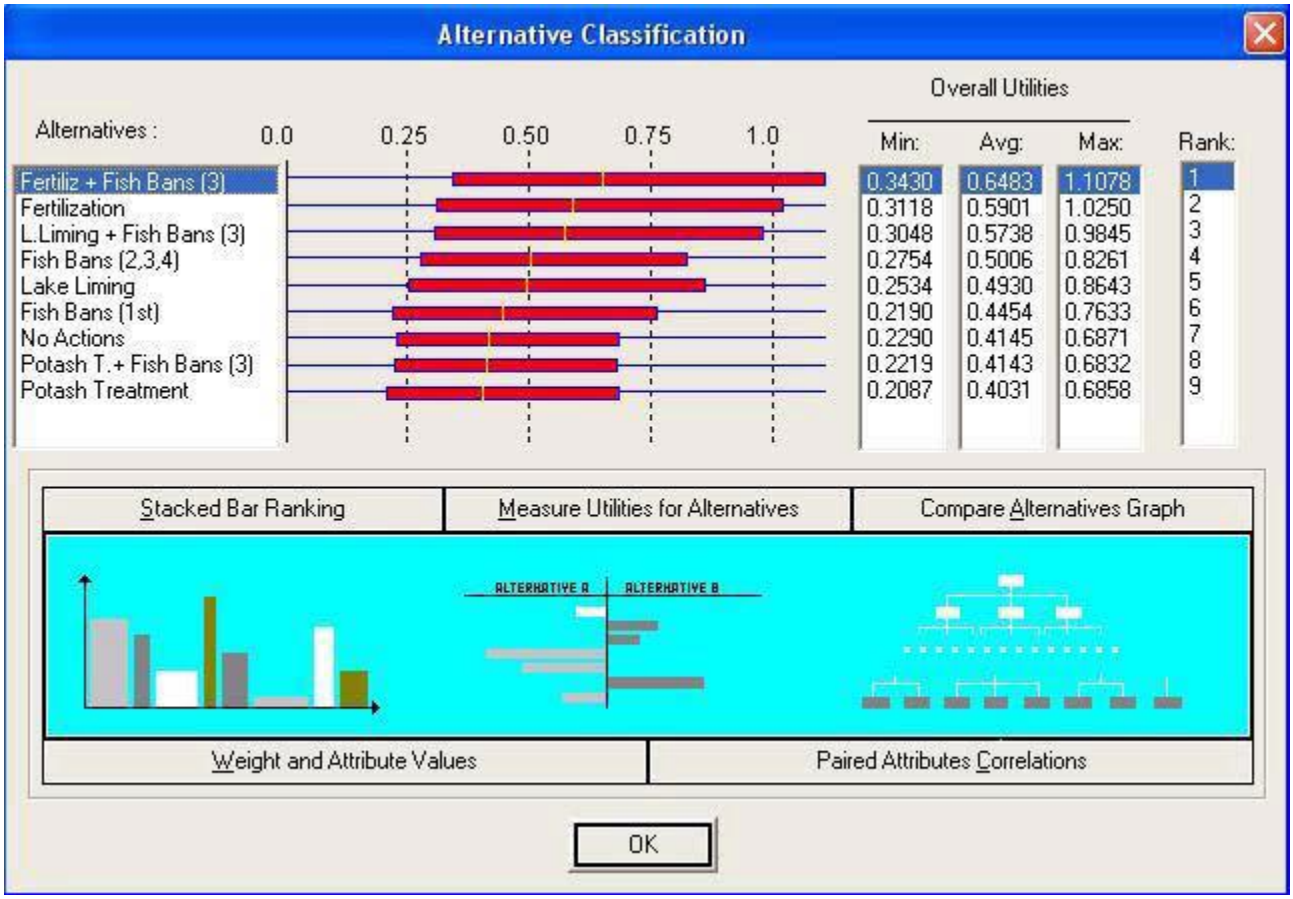
Value function intervals



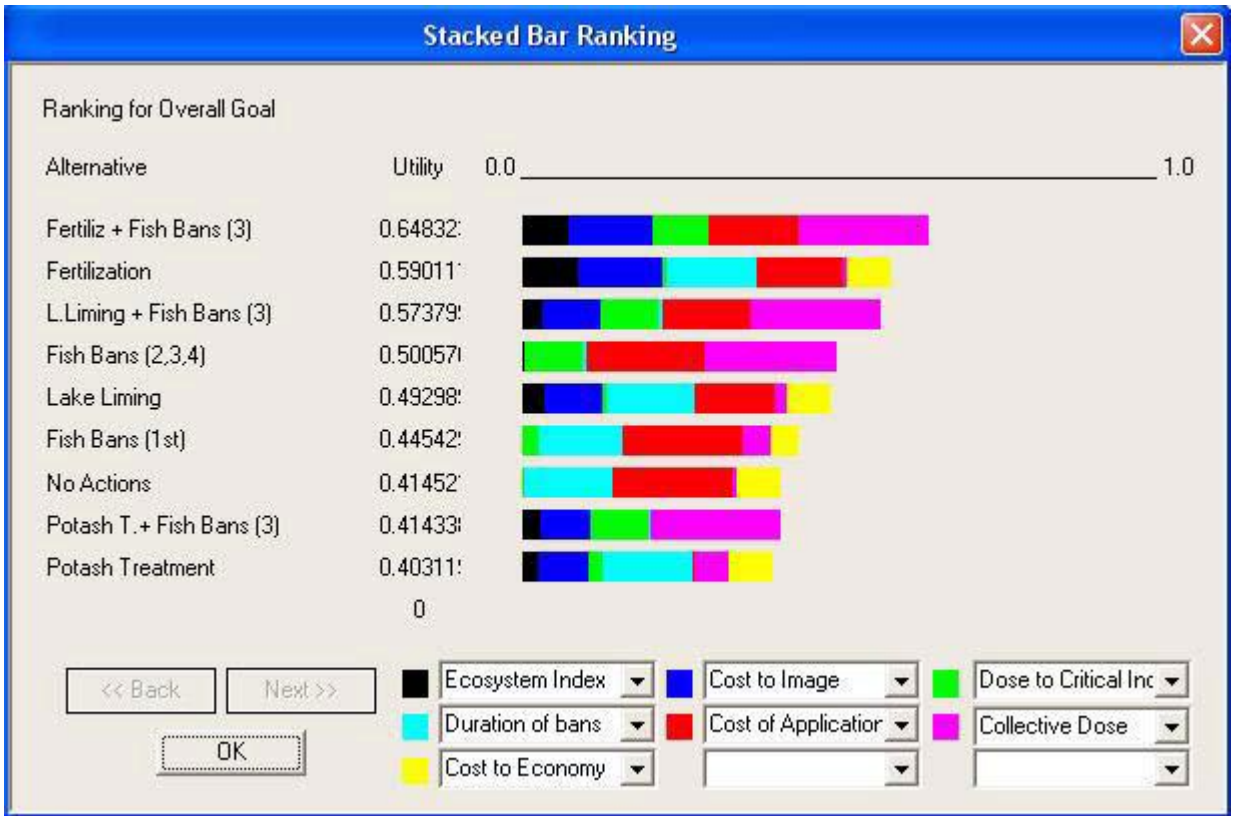
Trade-offs



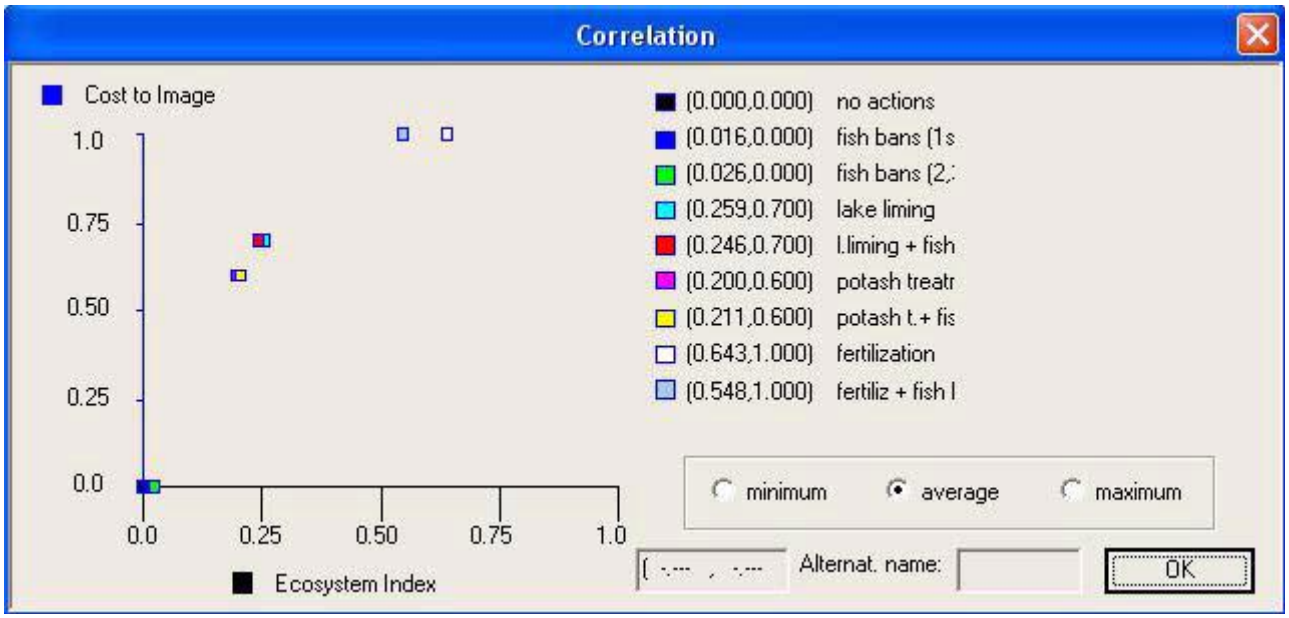
Weight intervals



Overall value intervals

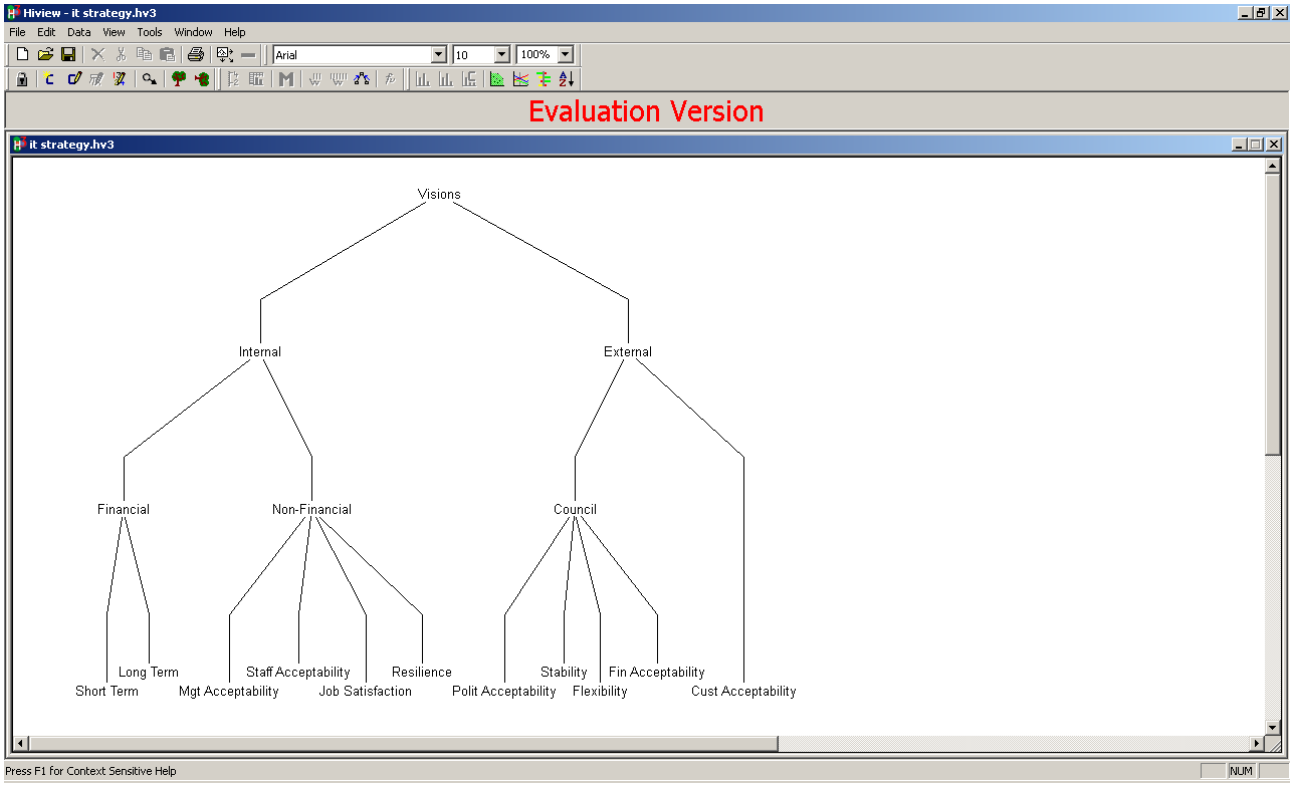


Overall values

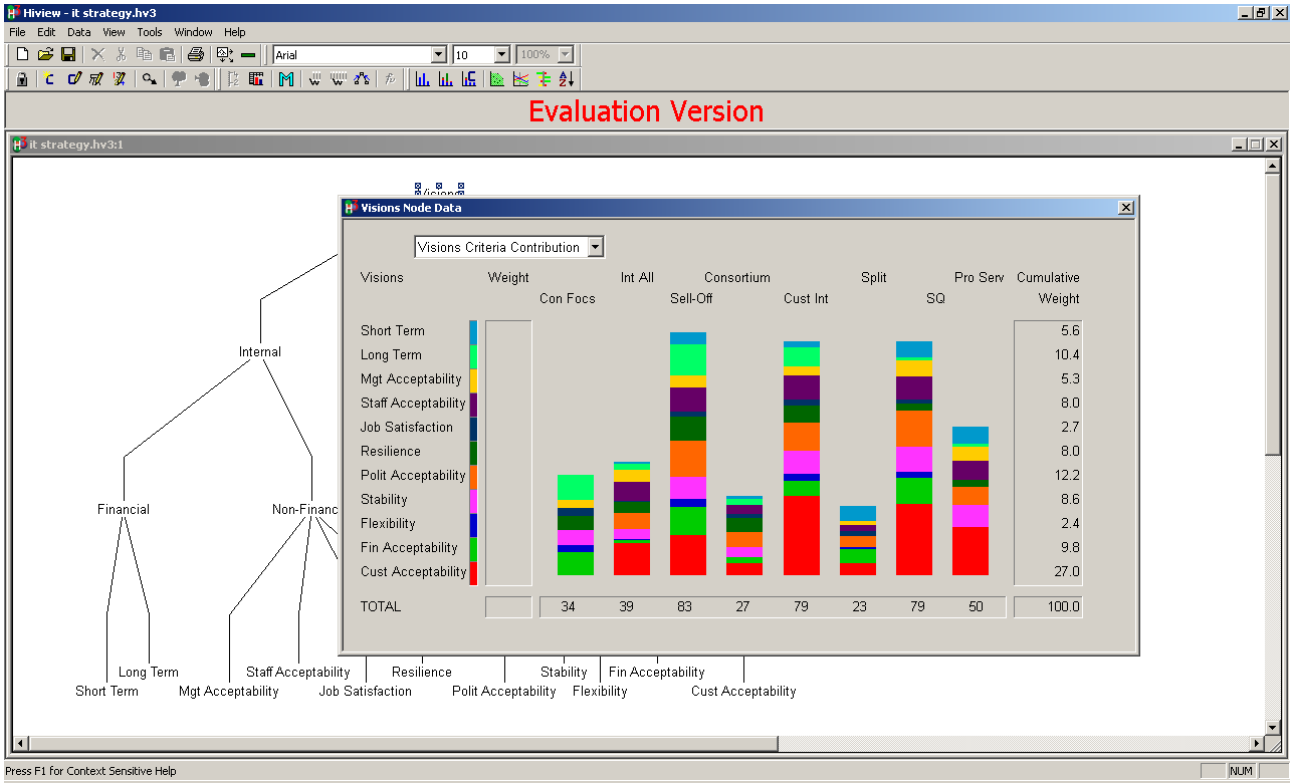


Correlation

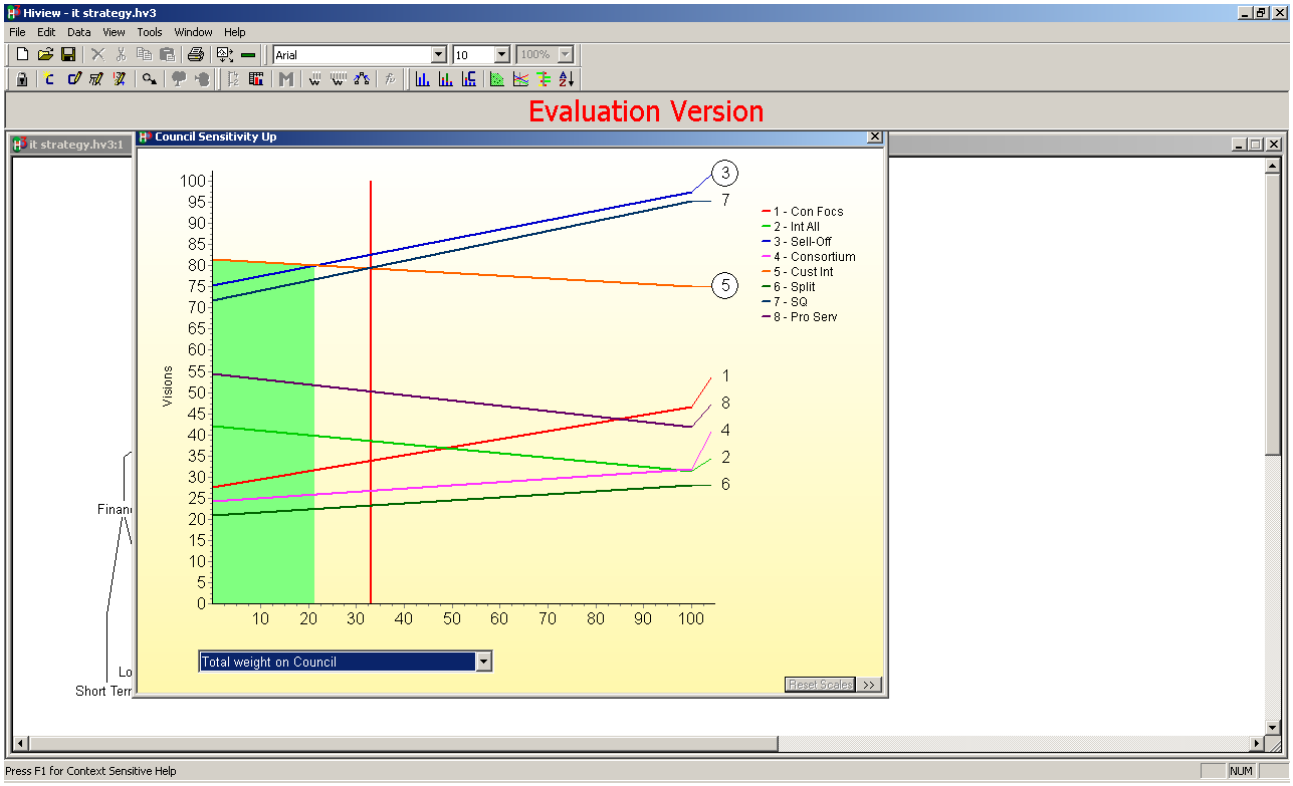
HiView 3



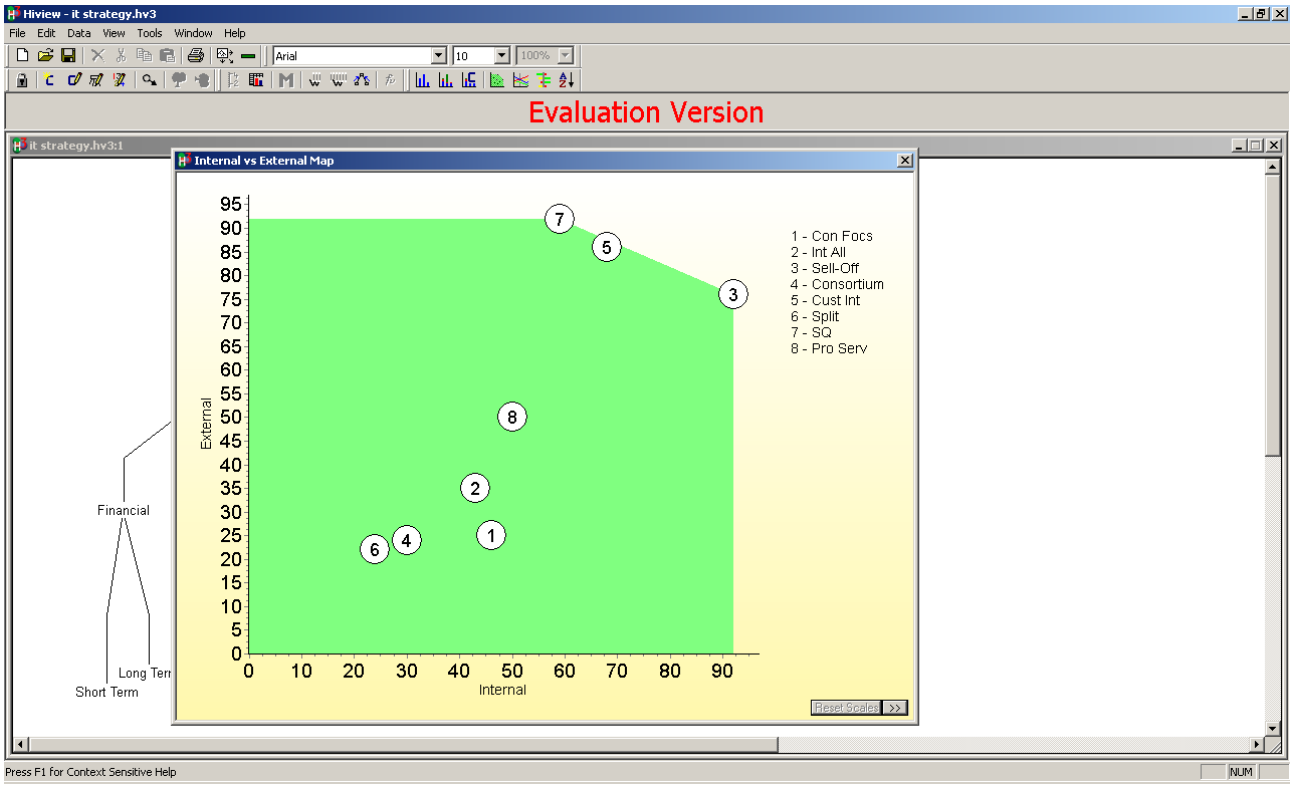
Value tree



Criteria contribution

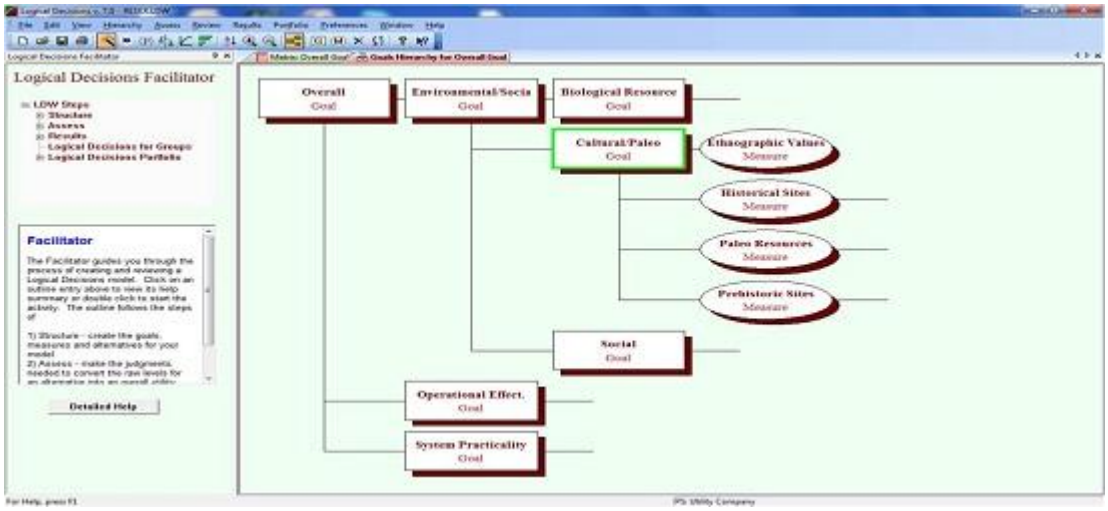


Sensitivity graph

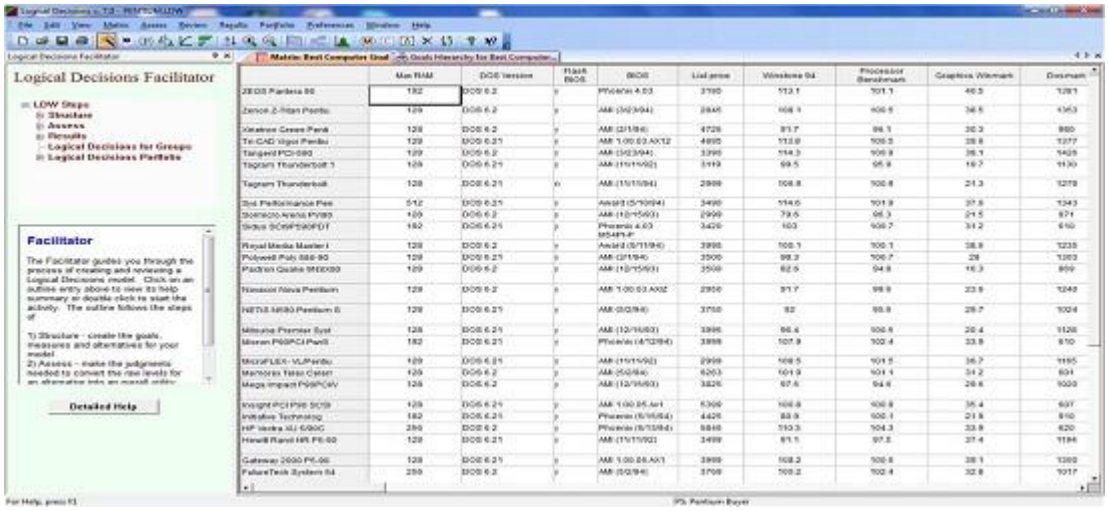


Two-dimensional graph

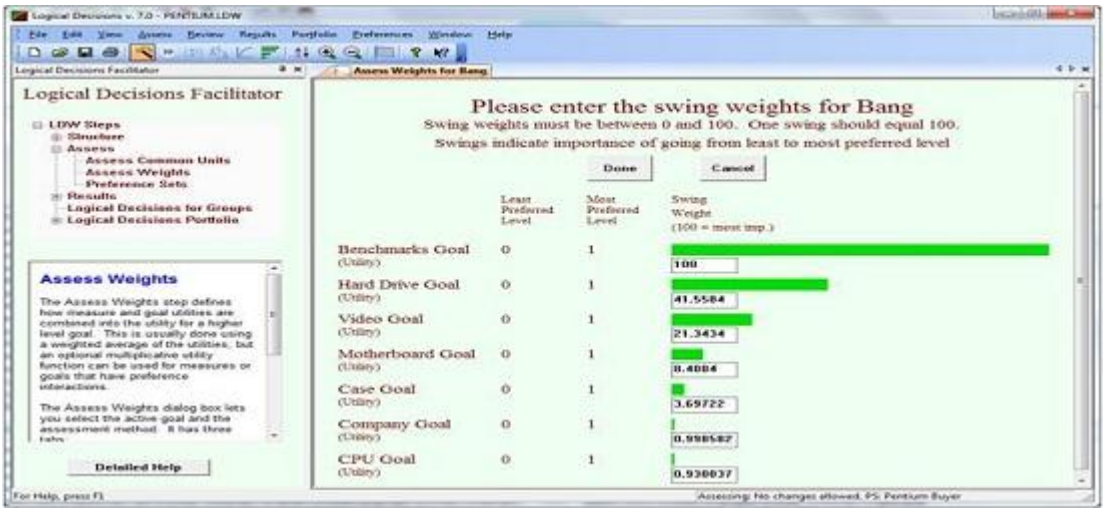
Logical Decisions



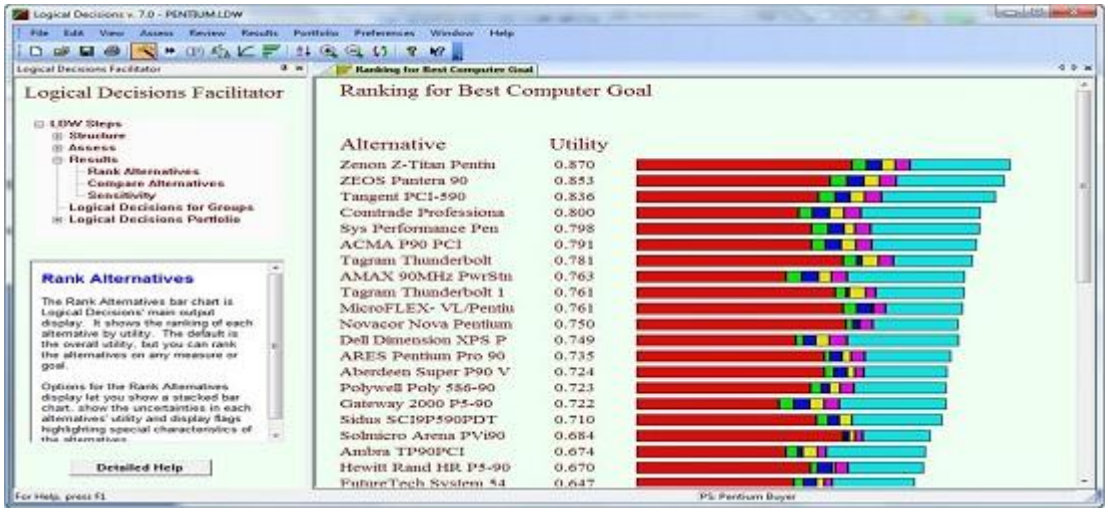
Hierarchy



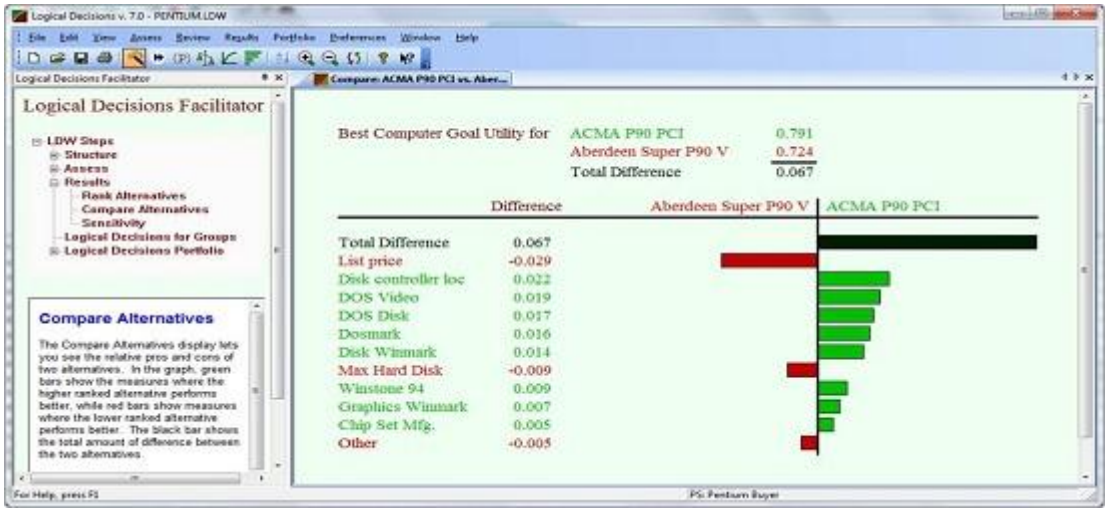
Consequences table



Swing weighting

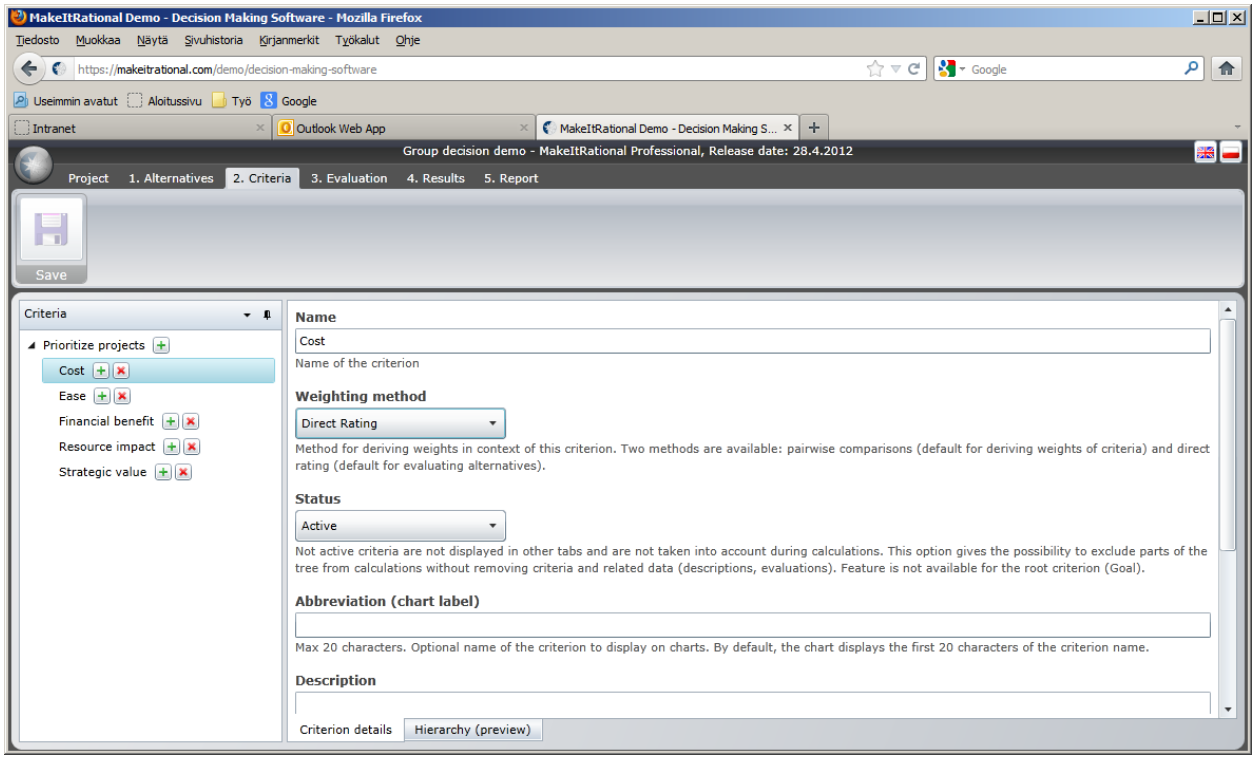


Overall values

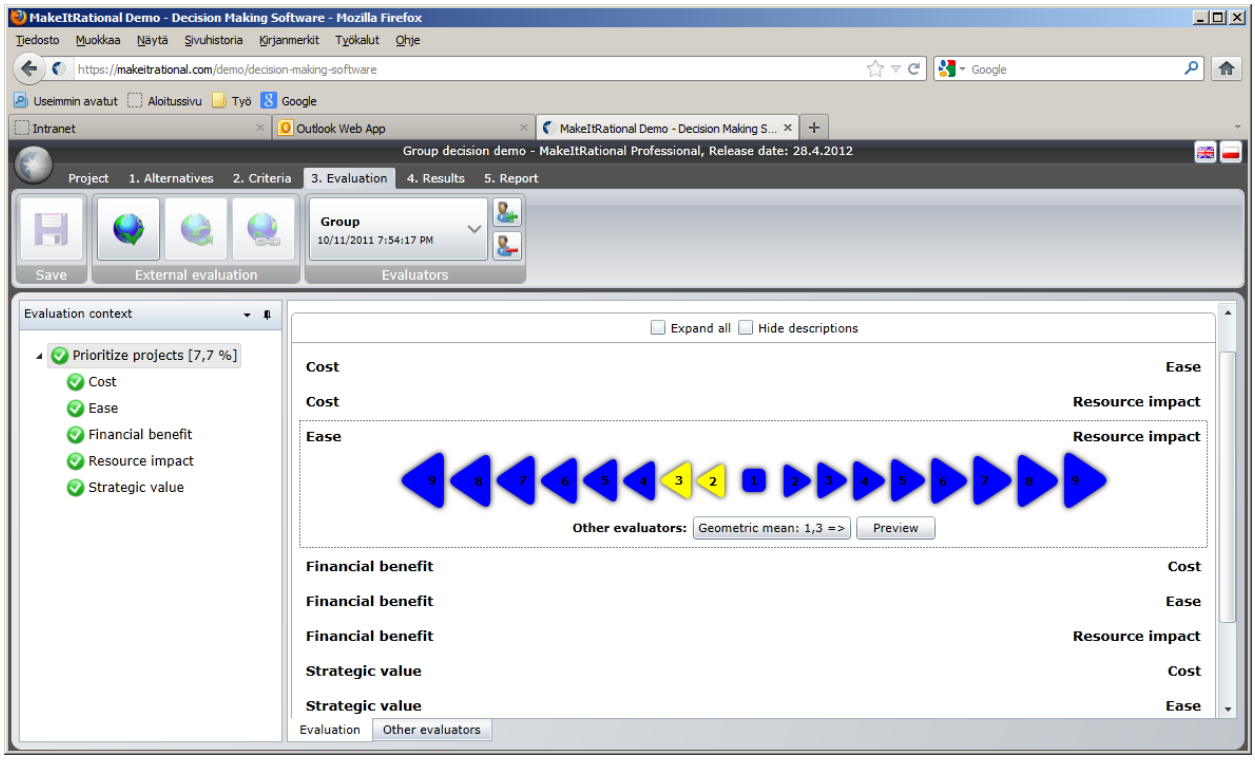


Tornado graph

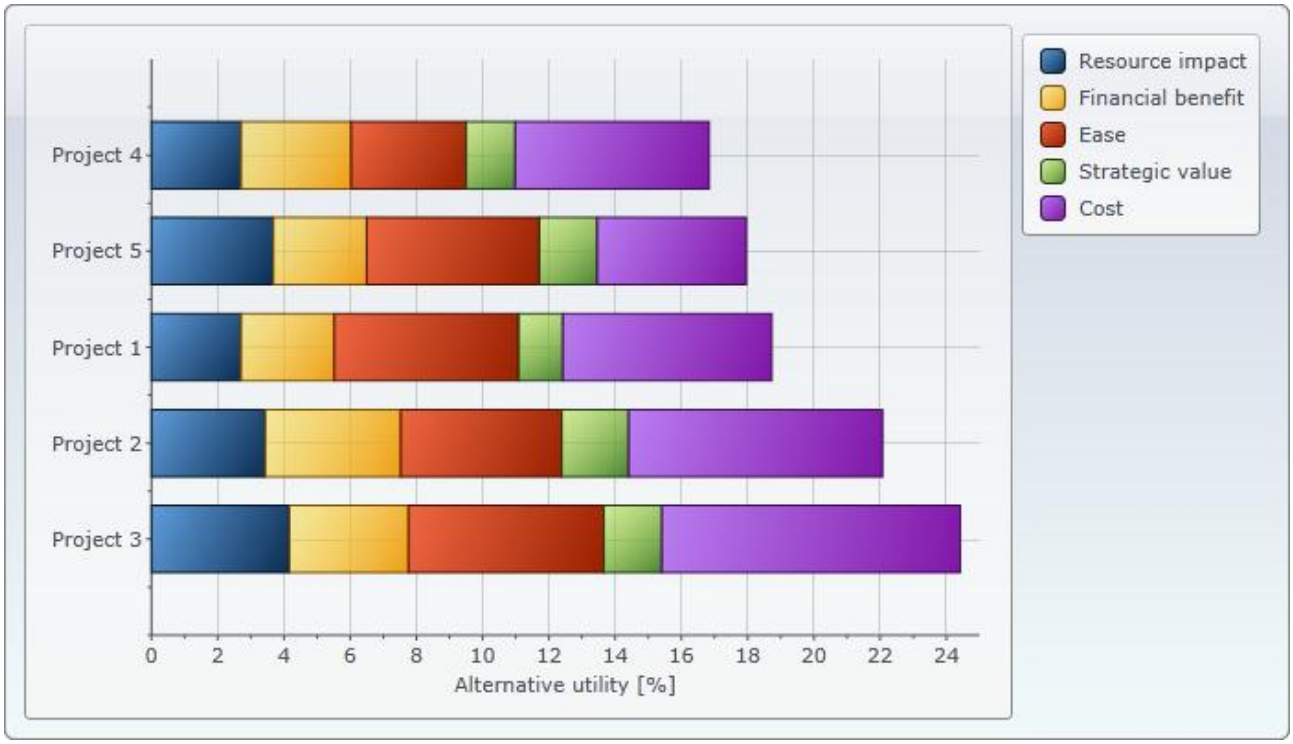
MakeItRational



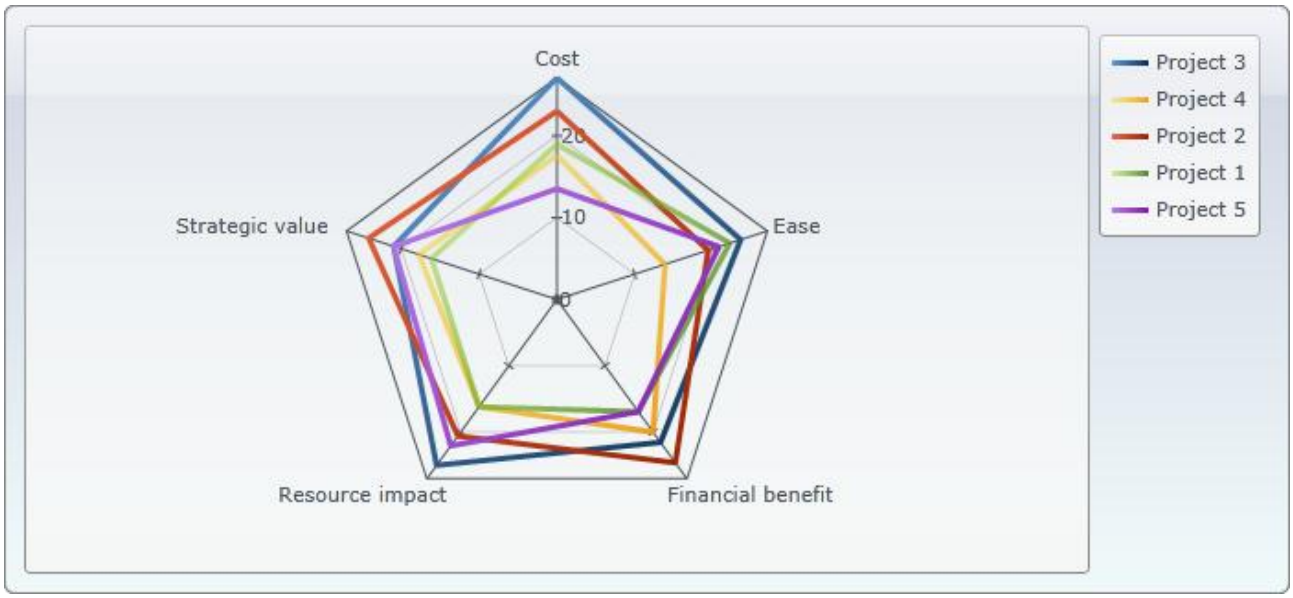
Problem initialization



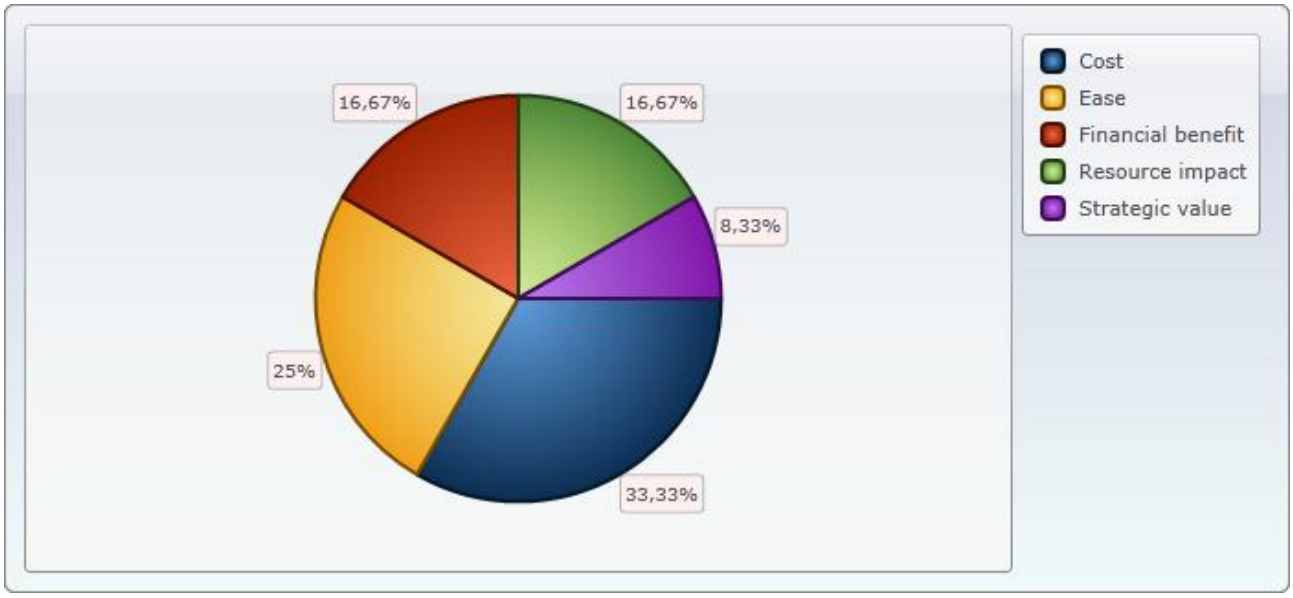
Pairwise comparisons



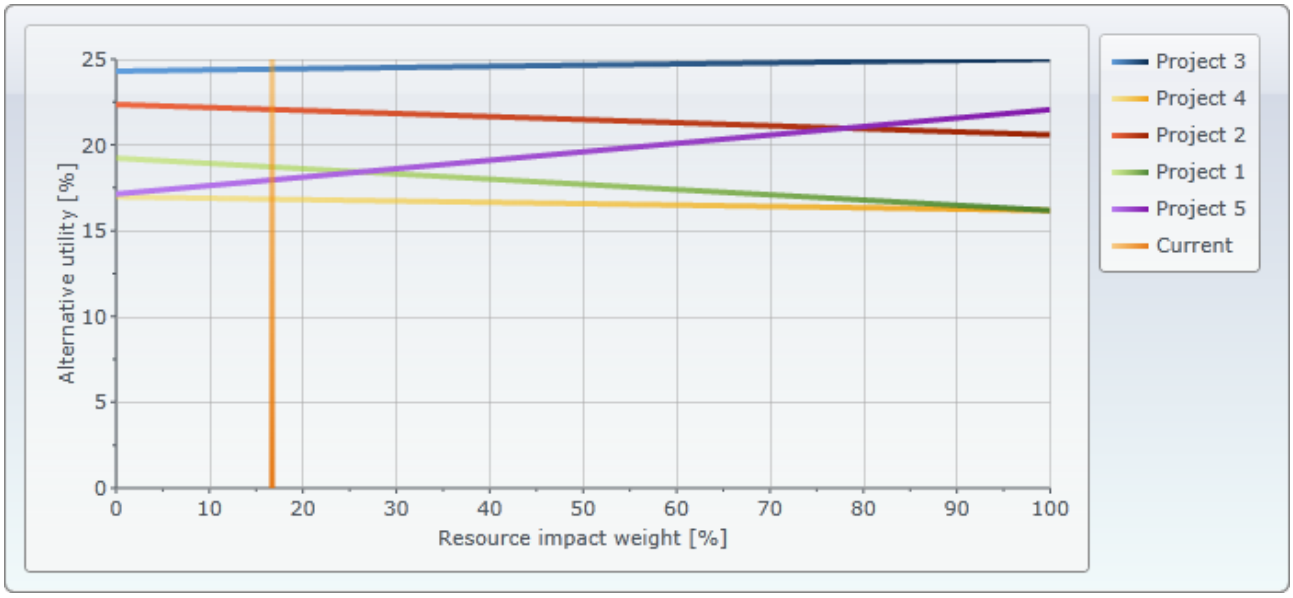
Overall values



Spider graph

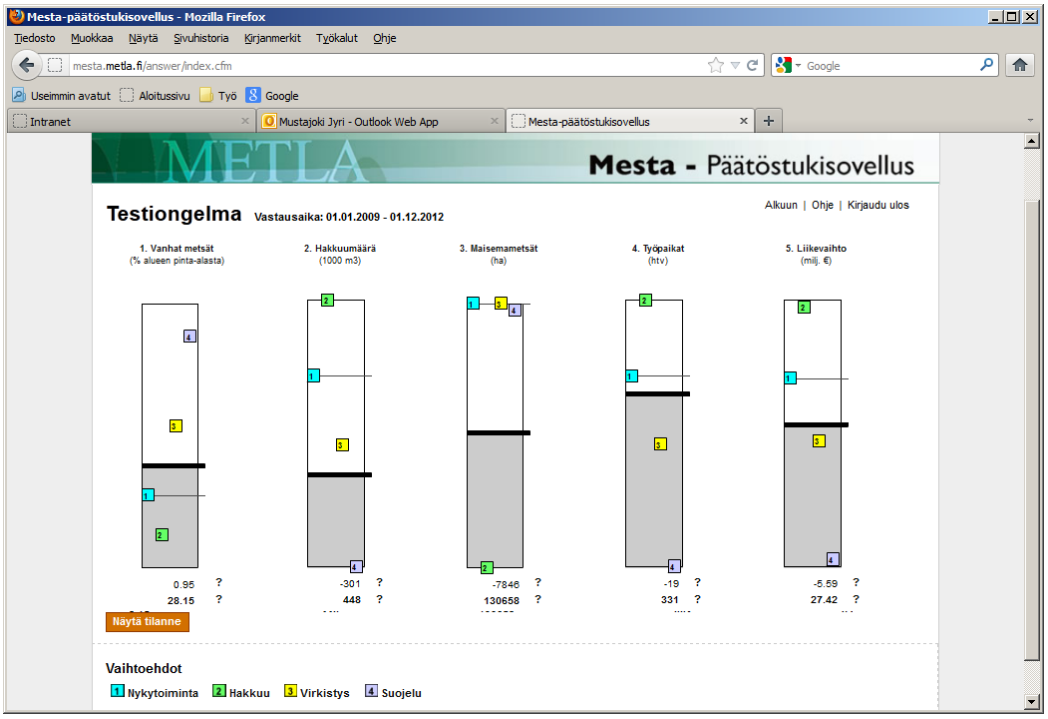


Criteria weights

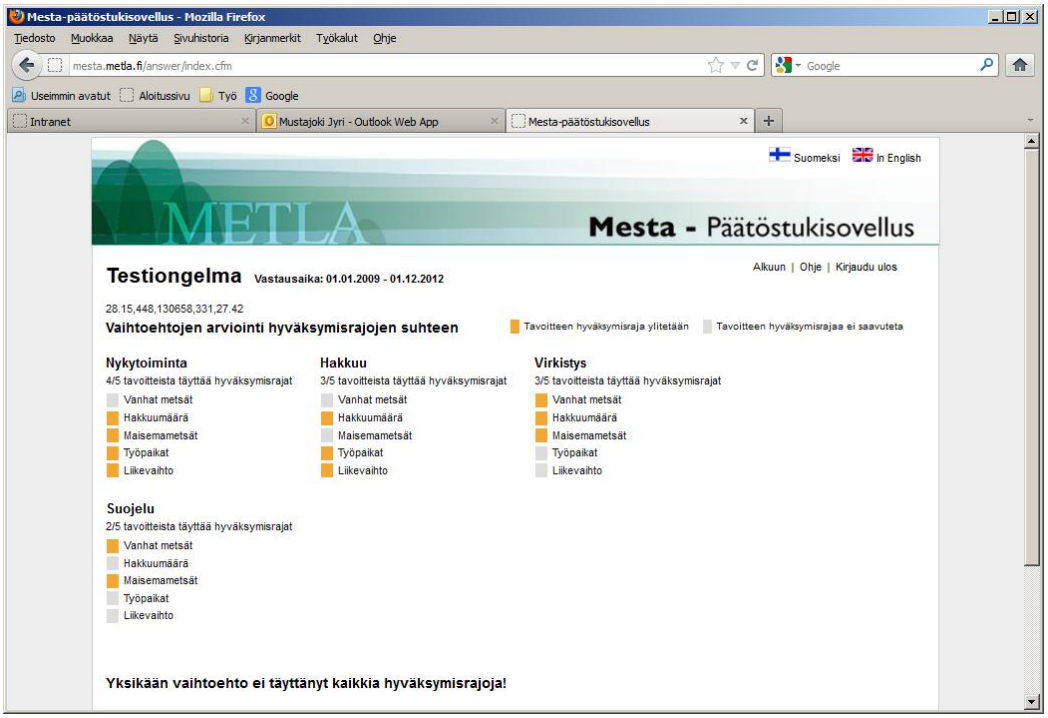


Sensitivity analysis

MESTA

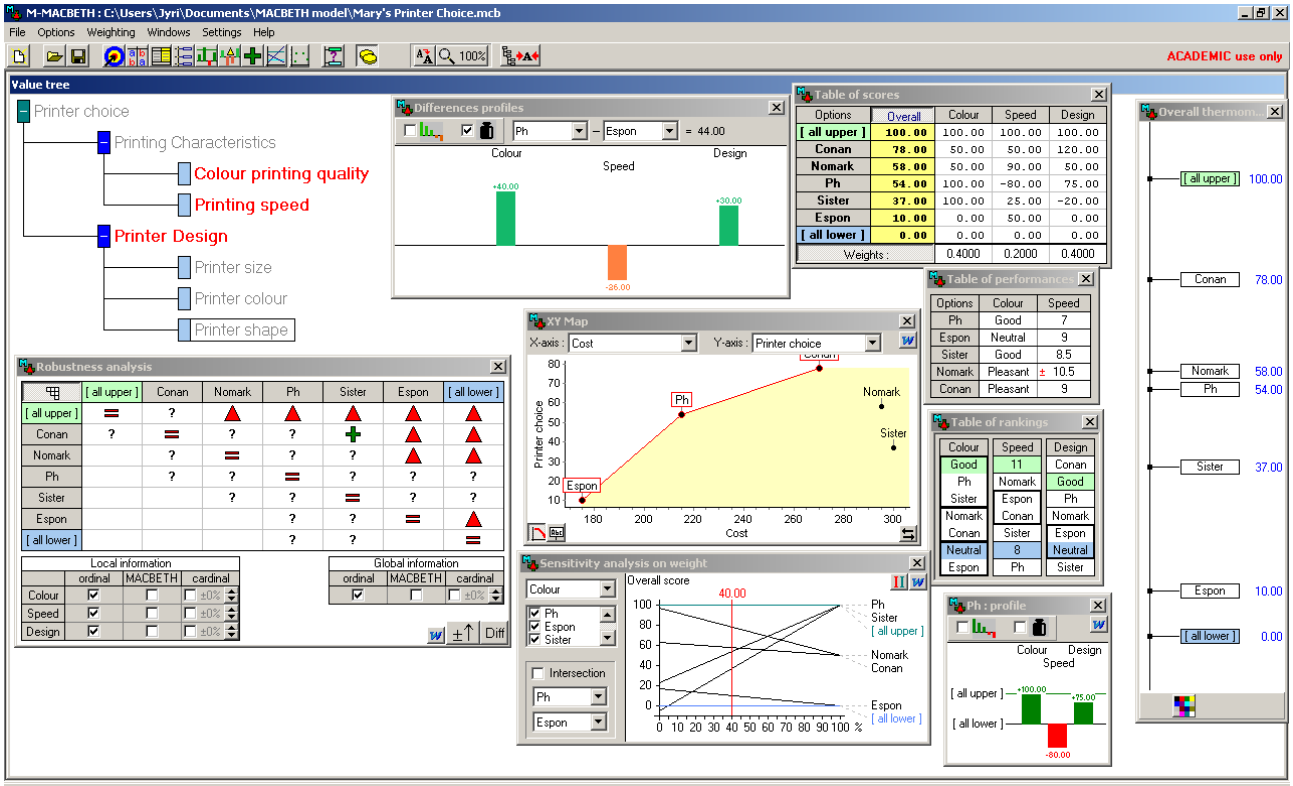


Setting of threshold values

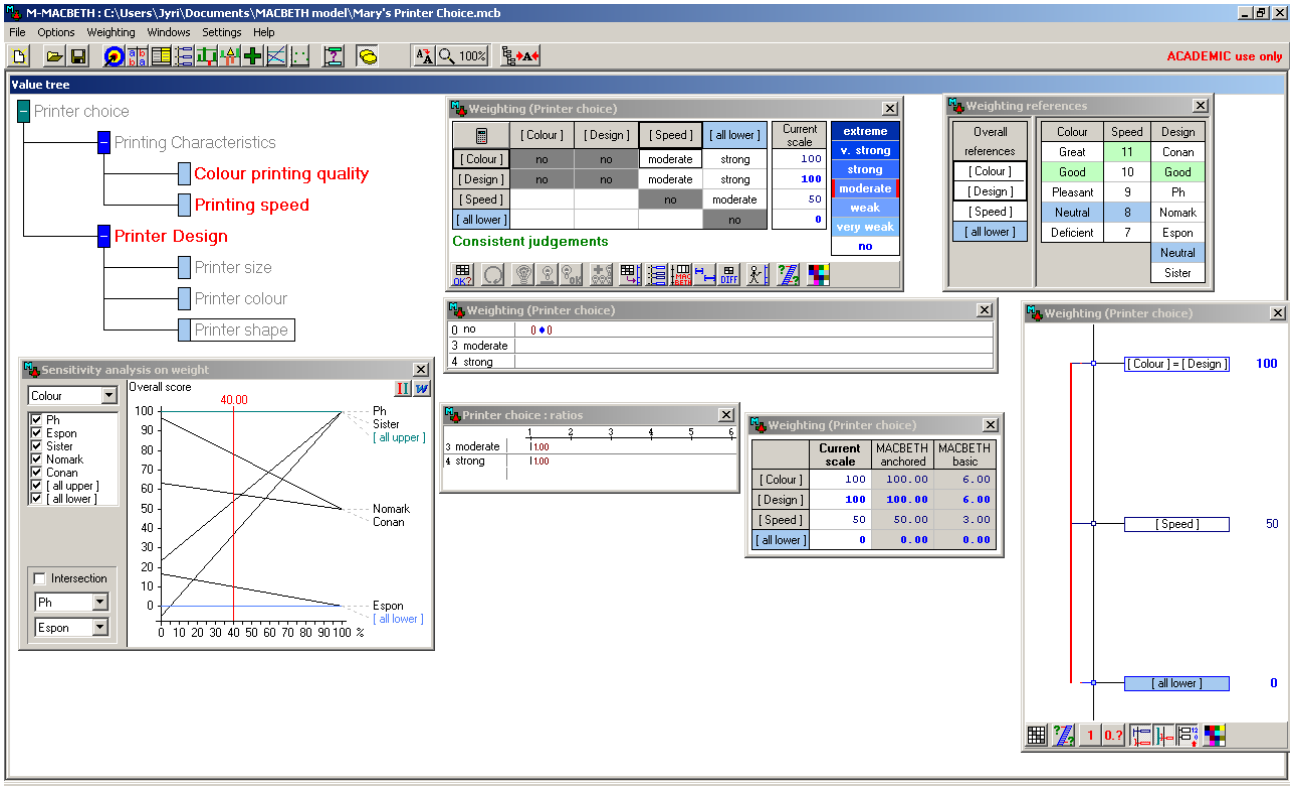


Evaluation of the alternatives

M-MACBETH

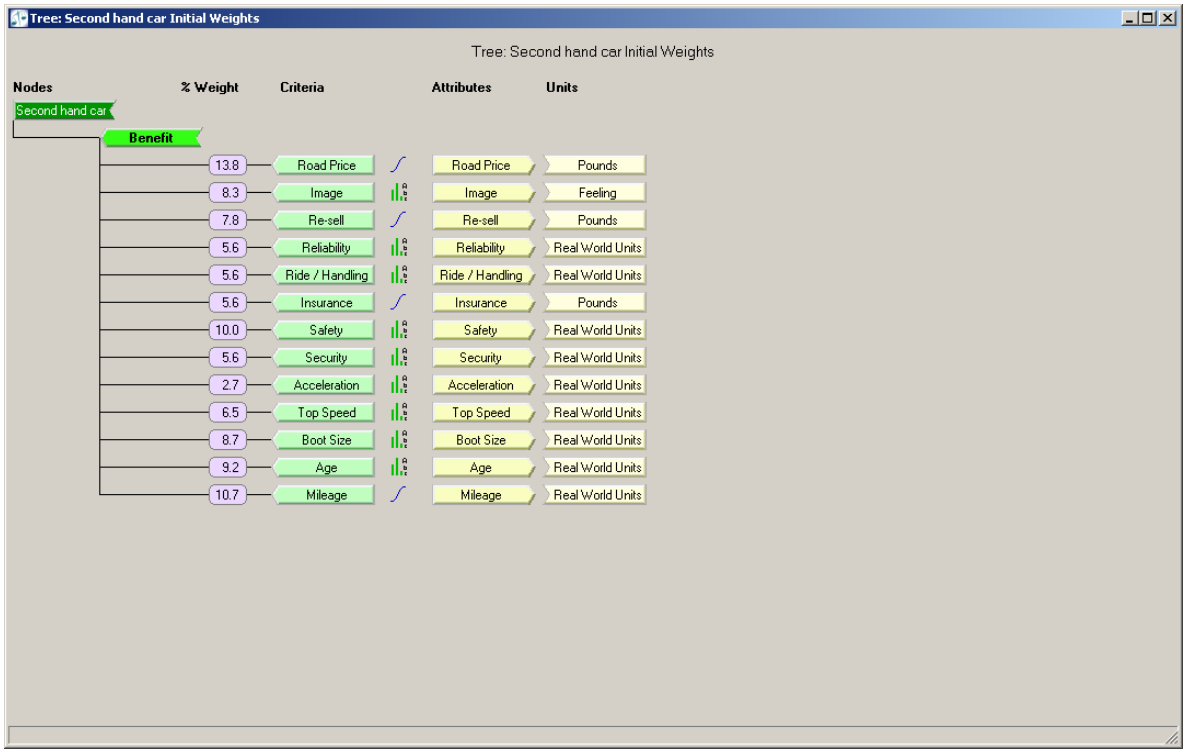


Options

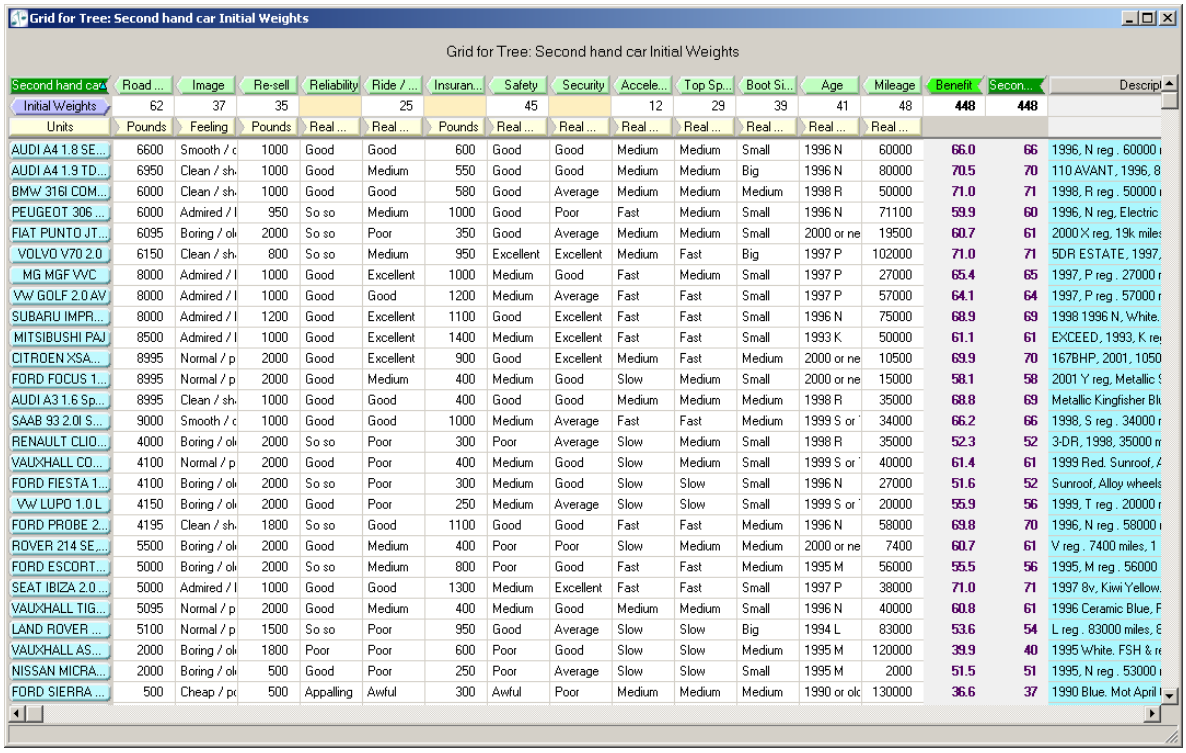


Weighting

OnBalance

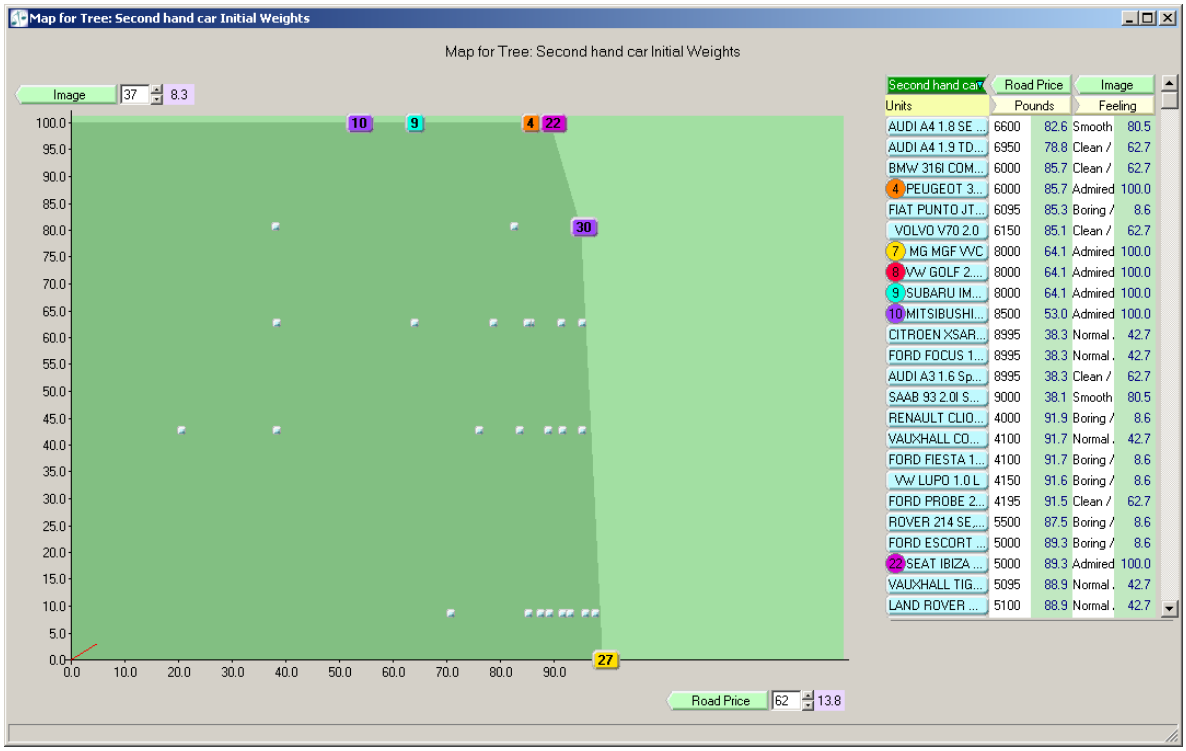


Value tree with weights

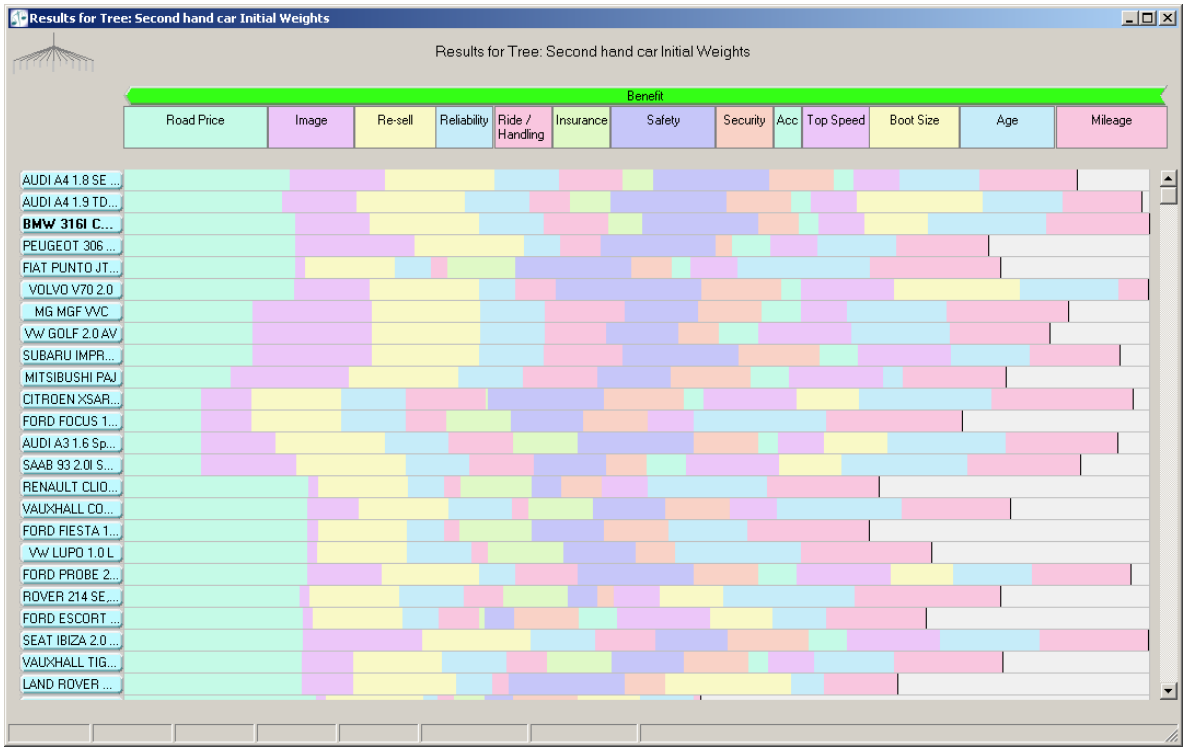


Second hand car	Road ...	Image	Re-sell	Reliability	Ride / ...	Insuran...	Safety	Security	Accele...	Top Sp...	Boot Si...	Age	Mileage	Benefit	Secon...	Descripl
Initial Weights	62	37	35		25		45		12	29	39	41	48	448	448	
Units	Pounds	Feeling	Pounds	Real ...	Real ...	Pounds	Real ...	Real ...	Real ...	Real ...	Real ...	Real ...	Real ...			
AUDI A4 1.8 SE...	6600	Smooth / c	1000	Good	Good	600	Good	Good	Medium	Medium	Small	1996 N	60000	66.0	66	1996, N reg . 60000 r
AUDI A4 1.9 TD...	6950	Clean / sh	1000	Good	Medium	550	Good	Good	Medium	Medium	Big	1996 N	80000	70.5	70	110 AVANT, 1996, 8
BMW 316I COM...	6000	Clean / sh	1000	Good	Good	580	Good	Average	Medium	Medium	Medium	1998 R	50000	71.0	71	1998, R reg . 50000 r
PEUGEOT 306 ...	6000	Admired / I	950	So so	Medium	1000	Good	Poor	Fast	Medium	Small	1996 N	71100	59.9	60	1996, N reg, Electric
FIAT PUNTO JT...	6095	Boring / ol	2000	So so	Poor	350	Good	Average	Medium	Medium	Small	2000 or ne	19500	60.7	61	2000 X reg, 19k miles
VOLVO V70 2.0	6150	Clean / sh	800	So so	Medium	950	Excellent	Excellent	Medium	Fast	Big	1997 P	102000	71.0	71	5DR ESTATE, 1997,
MG MGF VVC	8000	Admired / I	1000	Good	Excellent	1000	Medium	Good	Fast	Medium	Small	1997 P	27000	65.4	65	1997, P reg . 27000 r
VW GOLF 2.0 AV	8000	Admired / I	1000	Good	Good	1200	Medium	Average	Fast	Fast	Small	1997 P	57000	64.1	64	1997, P reg . 57000 r
SUBARU IMPR...	8000	Admired / I	1200	Good	Excellent	1100	Good	Excellent	Fast	Fast	Small	1996 N	75000	68.9	69	1998 1996 N, White.
MITSIBUSHI PAJ	8500	Admired / I	1000	Good	Excellent	1400	Medium	Excellent	Fast	Fast	Small	1993 K	50000	61.1	61	EXCEED, 1993, K re
CITROEN XSA...	8995	Normal / p	2000	Good	Excellent	900	Good	Excellent	Medium	Fast	Medium	2000 or ne	10500	69.9	70	167BHP, 2001, 1050
FORD FOCUS 1...	8995	Normal / p	2000	Good	Medium	400	Medium	Good	Slow	Medium	Small	2000 or ne	15000	58.1	58	2001 Y reg, Metallic S
AUDI A3 1.6 Sp...	8995	Clean / sh	1000	Good	Good	400	Good	Good	Medium	Medium	Medium	1998 R	35000	68.8	69	Metallic Kingfisher Blu
SAAB 93 2.0I S...	9000	Smooth / c	1000	Good	Good	1000	Medium	Average	Fast	Fast	Medium	1999 S or	34000	66.2	66	1998, S reg . 34000 r
RENAULT CLIO...	4000	Boring / ol	2000	So so	Poor	300	Poor	Average	Slow	Medium	Small	1998 R	35000	52.3	52	3-DR, 1998, 35000 m
VAUXHALL CO...	4100	Normal / p	2000	Good	Poor	400	Medium	Good	Slow	Medium	Small	1999 S or	40000	61.4	61	1999 Red. Sunroof, A
FORD FIESTA 1...	4100	Boring / ol	2000	So so	Poor	300	Medium	Good	Slow	Slow	Small	1996 N	27000	51.6	52	Sunroof, Alloy wheels
VW LUPO 1.0 L	4150	Boring / ol	2000	Good	Poor	250	Medium	Average	Slow	Slow	Small	1999 S or	20000	55.9	56	1999, T reg . 20000 r
FORD PROBE 2...	4195	Clean / sh	1800	So so	Good	1100	Good	Good	Fast	Fast	Medium	1996 N	58000	69.8	70	1996, N reg . 58000 r
ROVER 214 SE,...	5500	Boring / ol	2000	Good	Medium	400	Poor	Poor	Slow	Medium	Medium	2000 or ne	7400	60.7	61	V reg . 7400 miles, 1
FORD ESCORT...	5000	Boring / ol	2000	So so	Medium	800	Poor	Good	Fast	Fast	Medium	1995 M	56000	55.5	56	1995, M reg . 56000
SEAT IBIZA 2.0 ...	5000	Admired / I	1000	Good	Good	1300	Medium	Excellent	Fast	Fast	Small	1997 P	38000	71.0	71	1997 8v, Kiwi Yellow.
VAUXHALL TIG...	5095	Normal / p	2000	Good	Medium	400	Medium	Good	Medium	Medium	Small	1996 N	40000	60.8	61	1996 Ceramic Blue, F
LAND ROVER ...	5100	Normal / p	1500	So so	Poor	950	Good	Average	Slow	Slow	Big	1994 L	83000	53.6	54	L reg . 83000 miles, E
VAUXHALL AS...	2000	Boring / ol	1800	Poor	Poor	600	Poor	Good	Slow	Slow	Medium	1995 M	120000	39.9	40	1995 White. FSH & re
NISSAN MICRA...	2000	Boring / ol	500	Good	Poor	250	Poor	Average	Slow	Slow	Small	1995 M	2000	51.5	51	1995, N reg . 53000 r
FORD SIERRA ...	500	Cheap / pc	500	Appalling	Awful	300	Awful	Poor	Medium	Medium	Medium	1990 or olc	130000	36.6	37	1990 Blue. Mot April

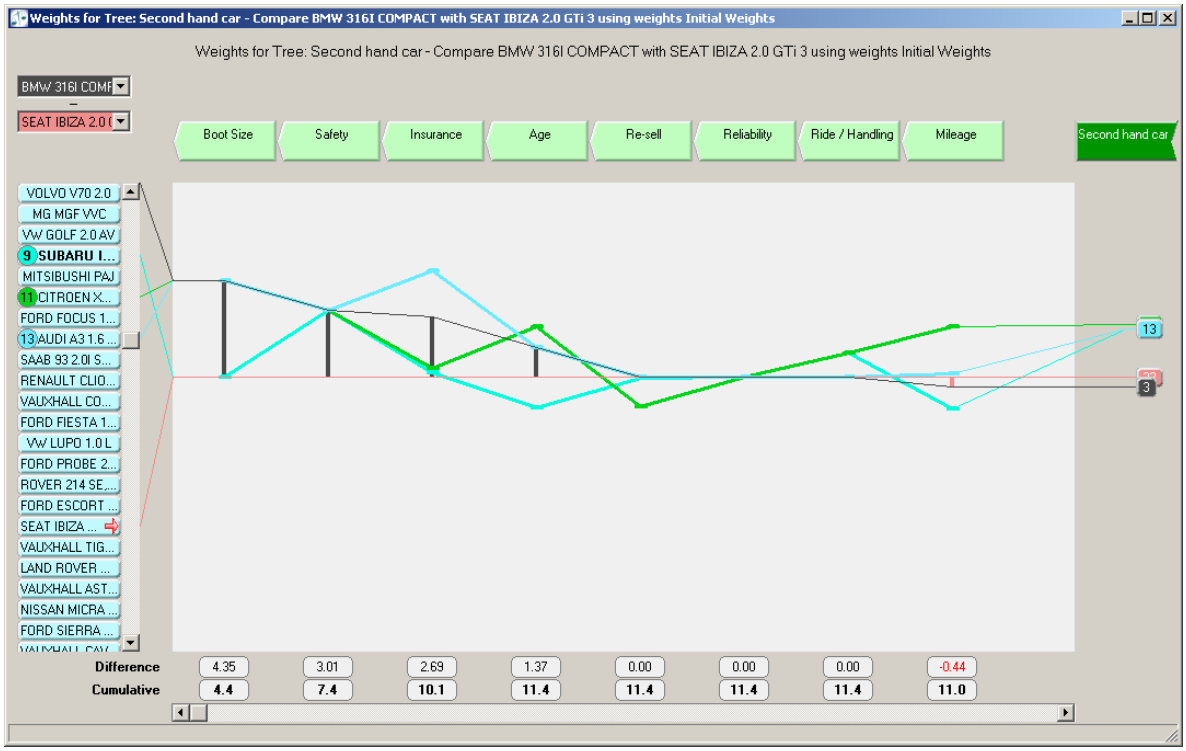
Evaluation table



Two-dimensional graph

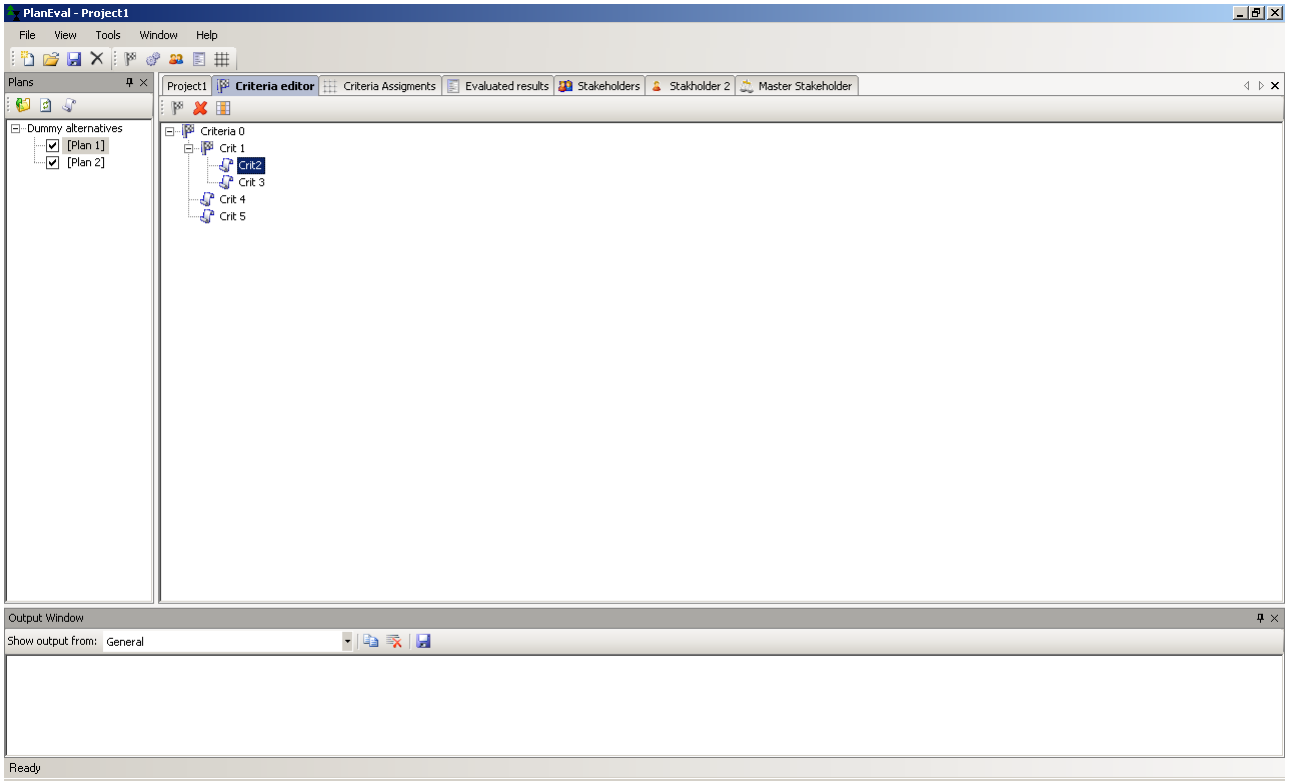


Overall values of the alternatives

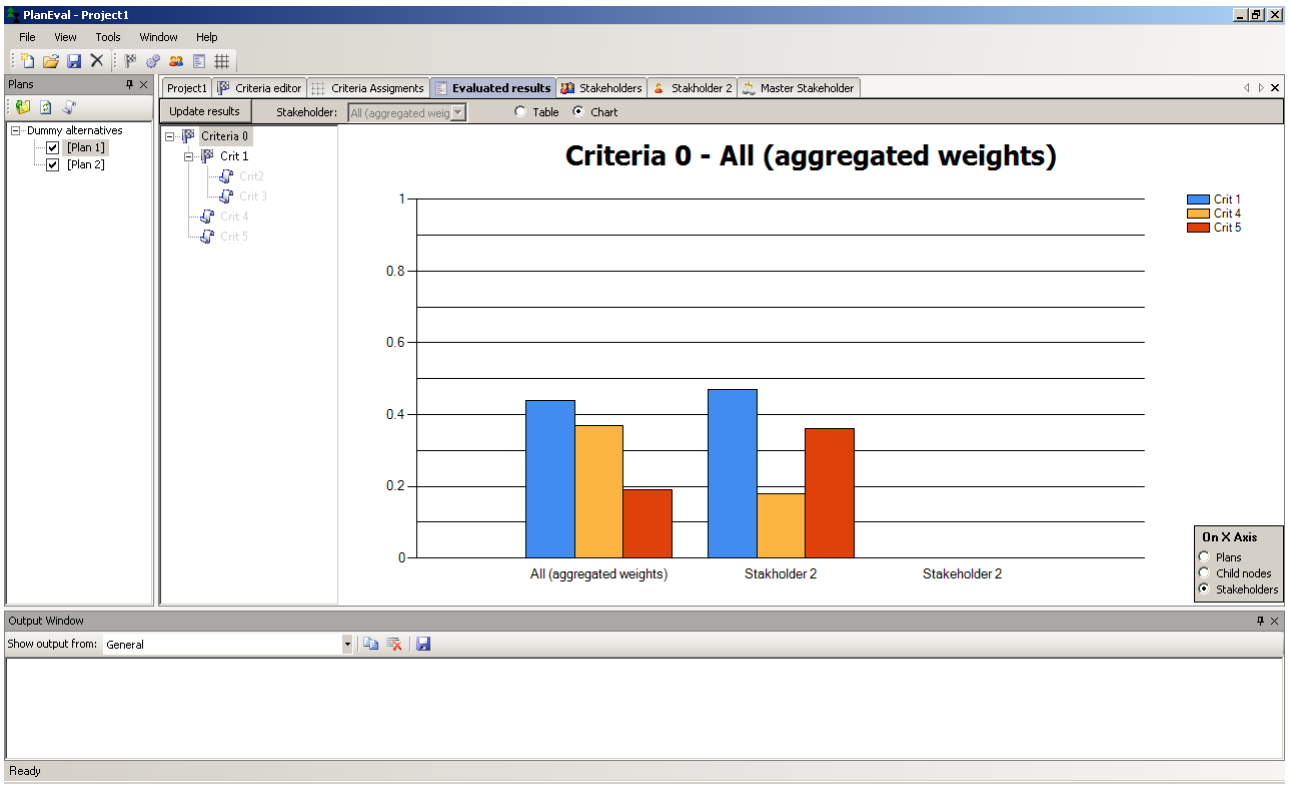


Pairwise analysis

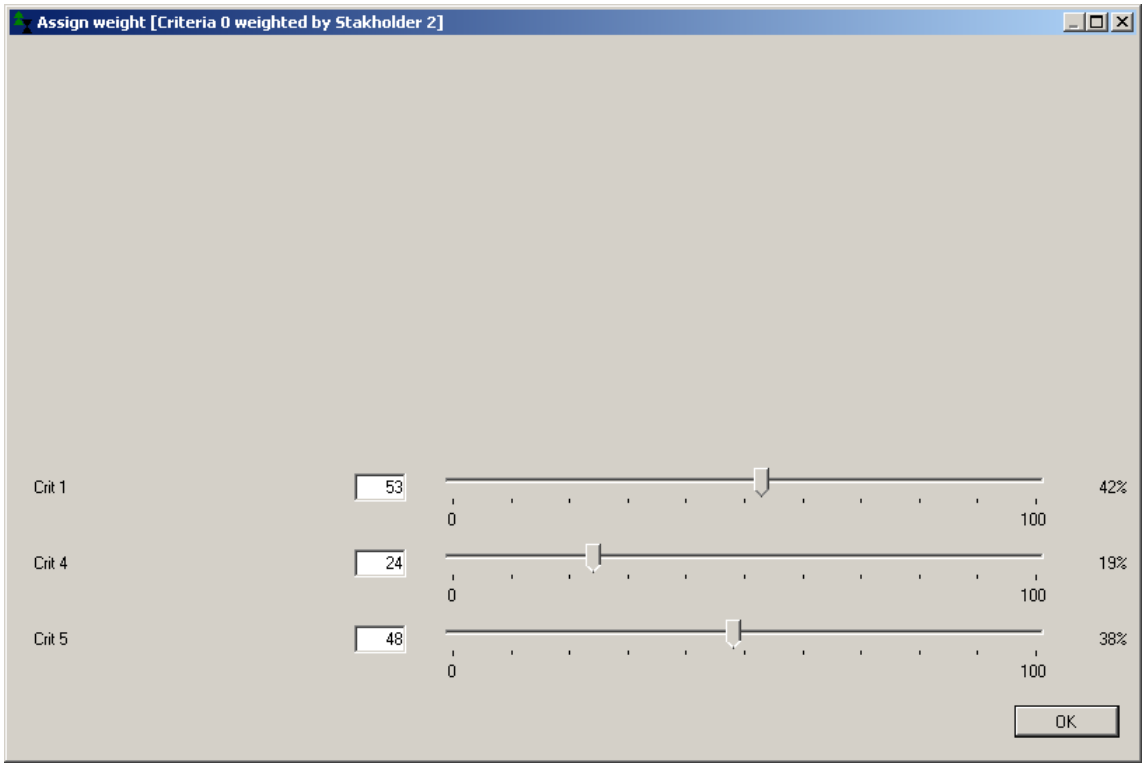
PlanEval



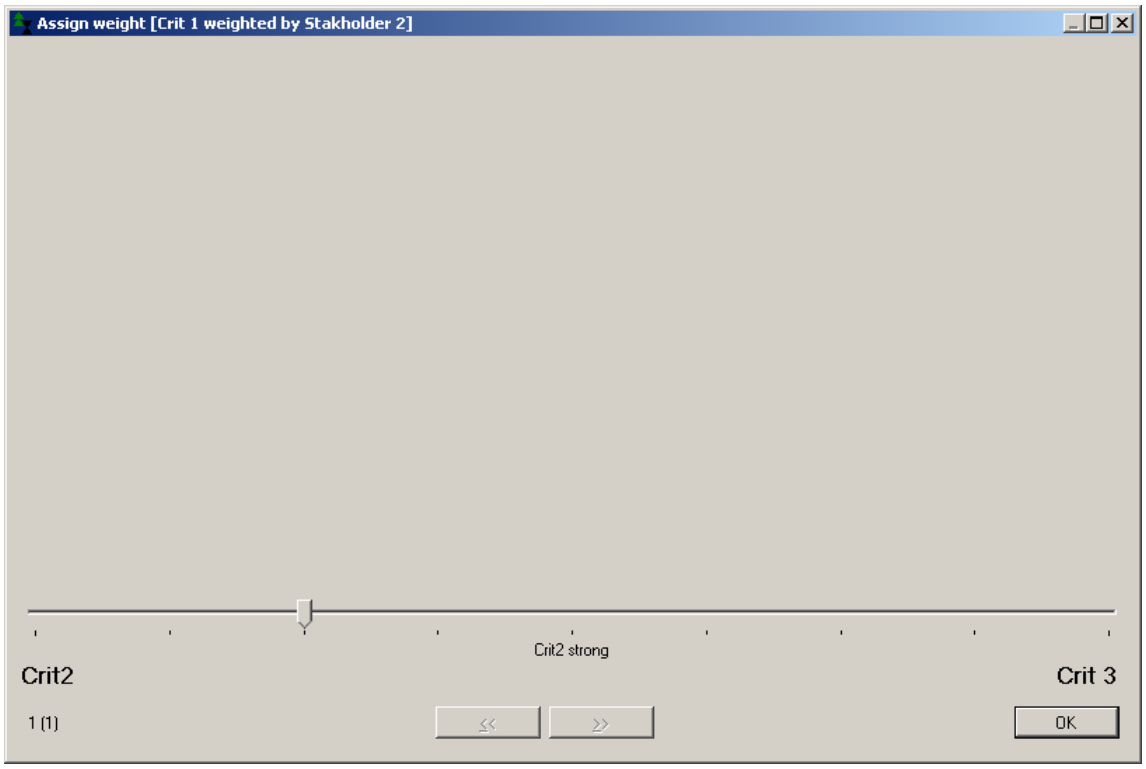
Hierarchy



Criteria weights

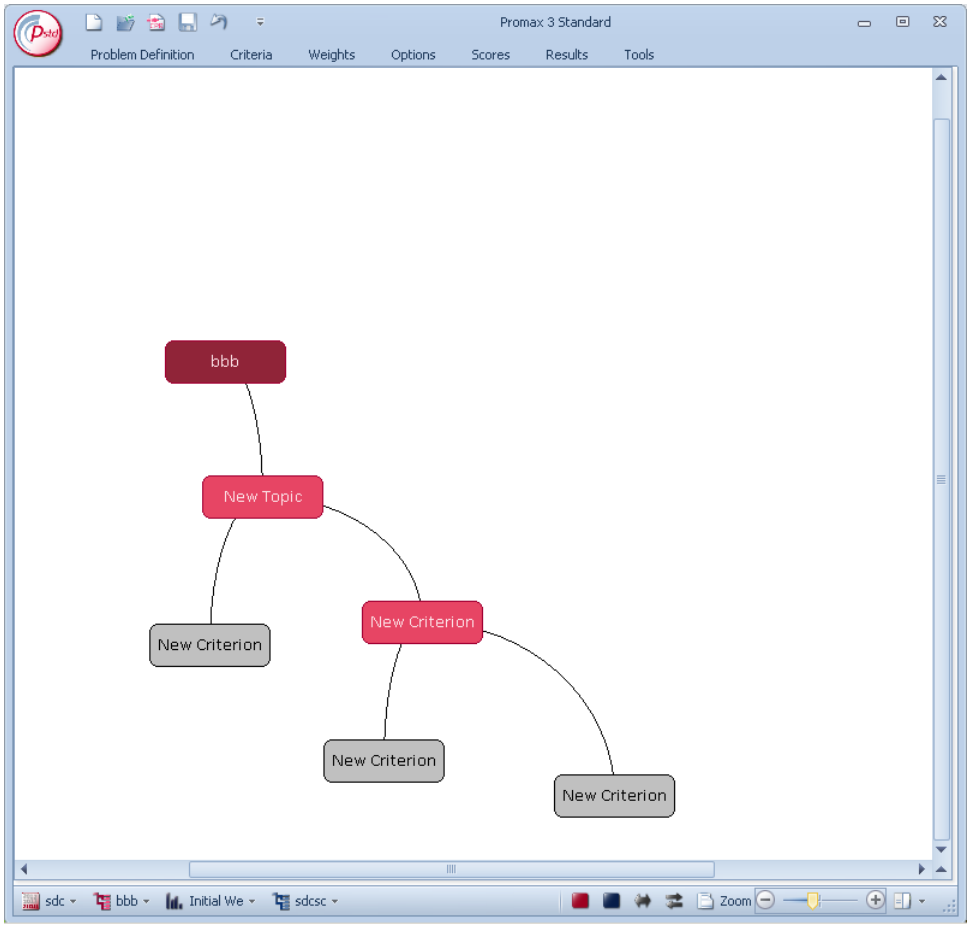


Weight setting

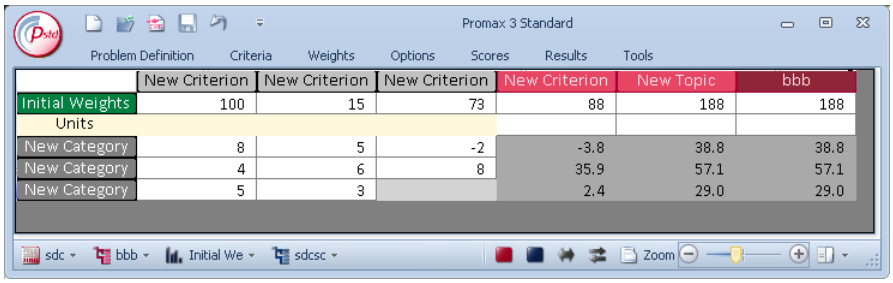


Weights setting

Promax

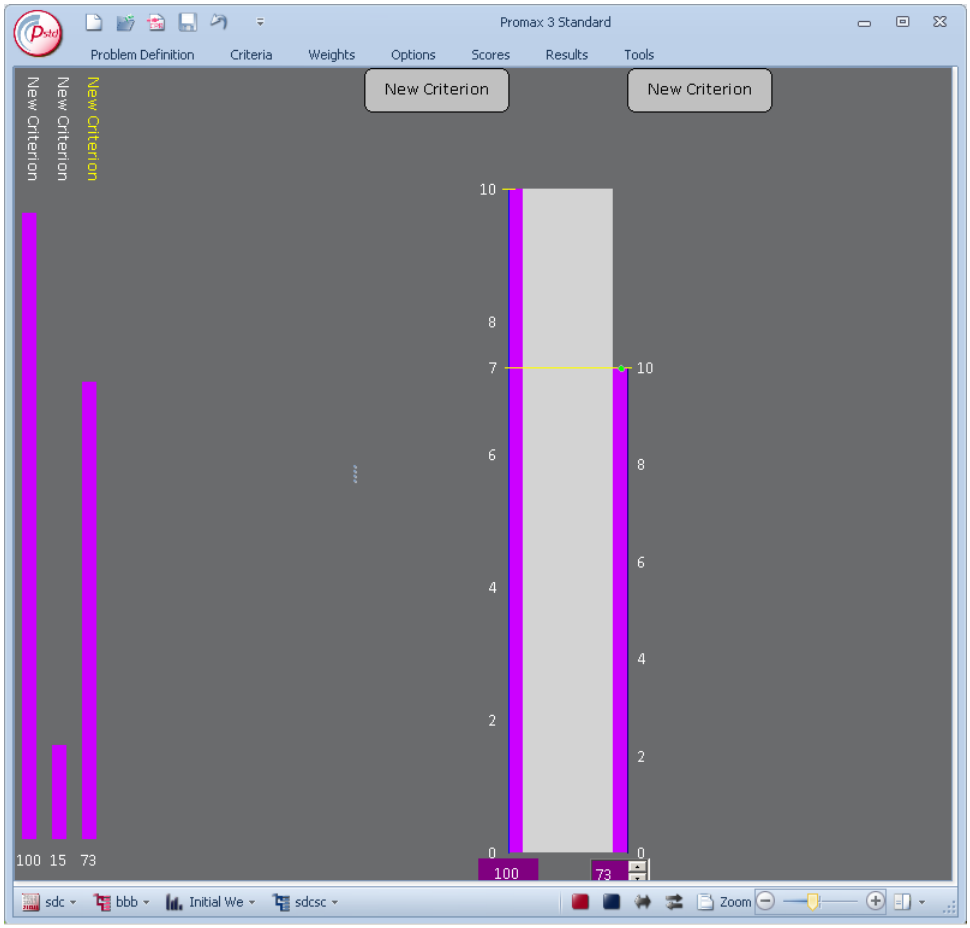


Value tree

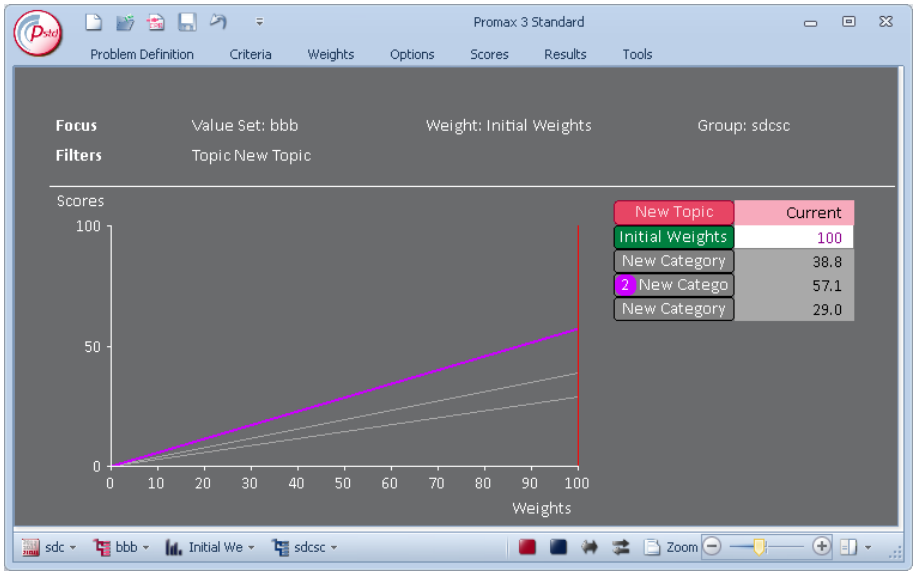


Consequences table

Weights

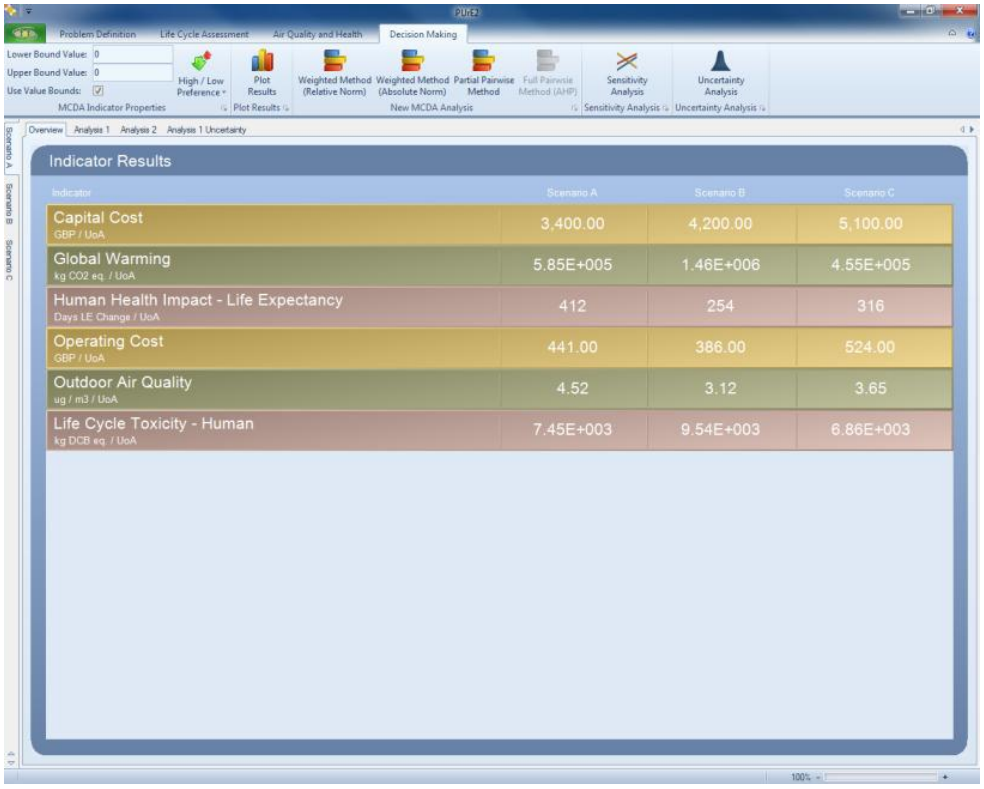


Overall values

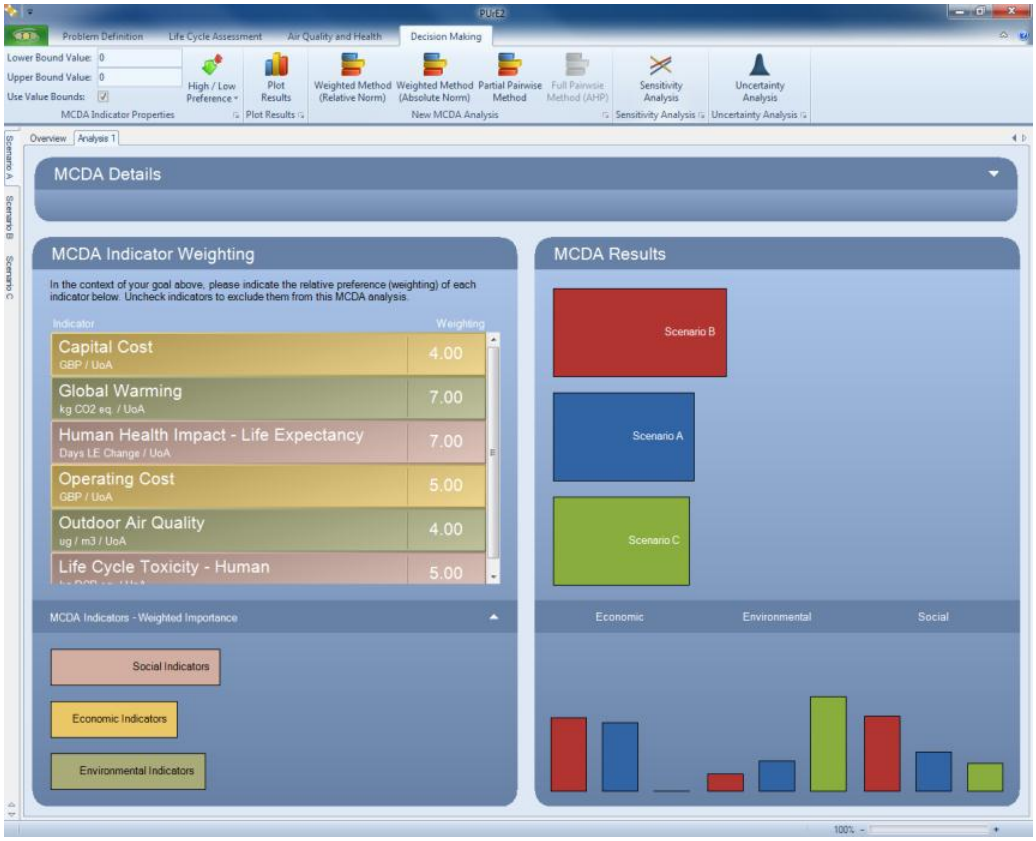


Sensitivity analysis

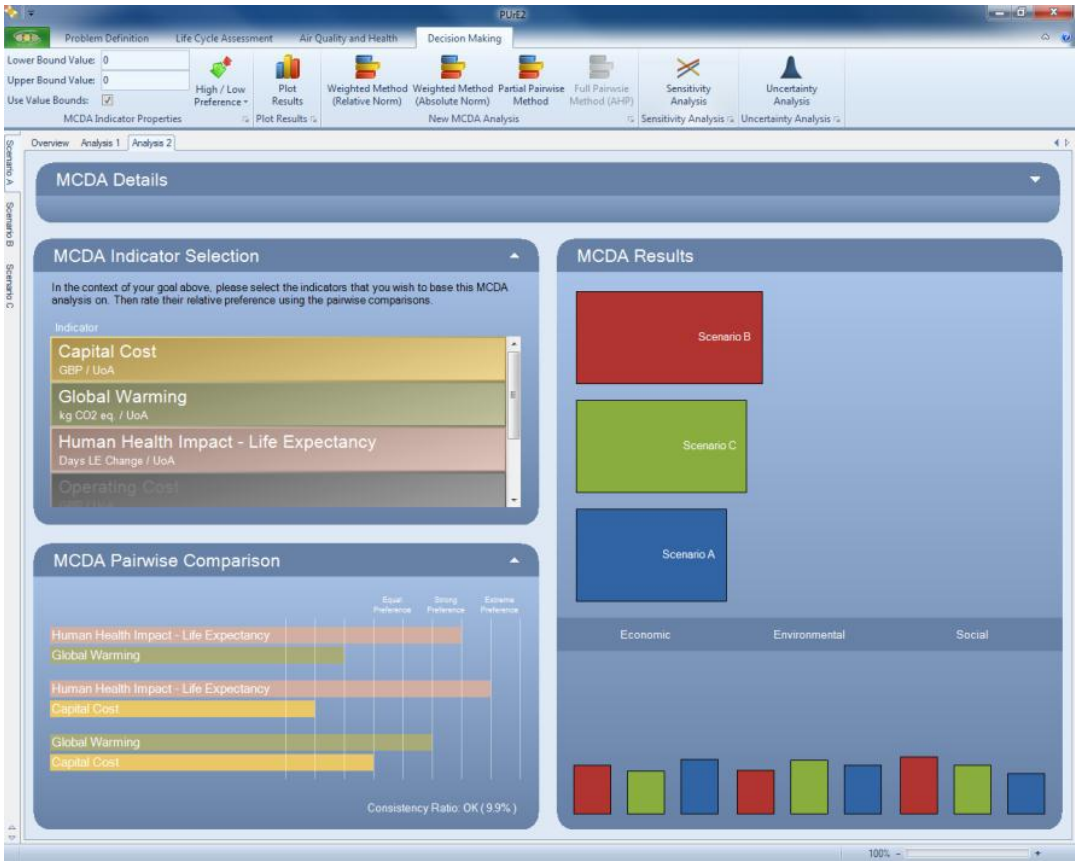
PUrE2 Software



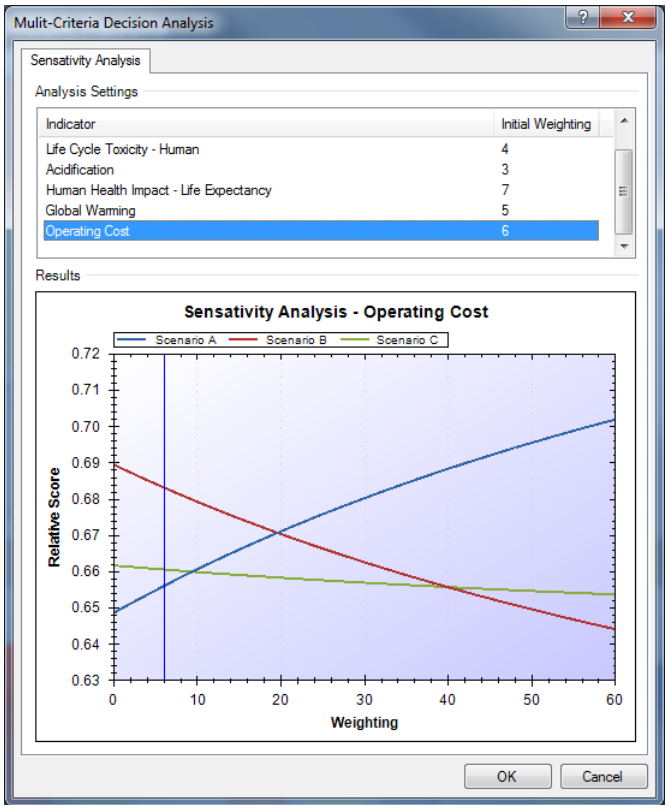
Consequence table



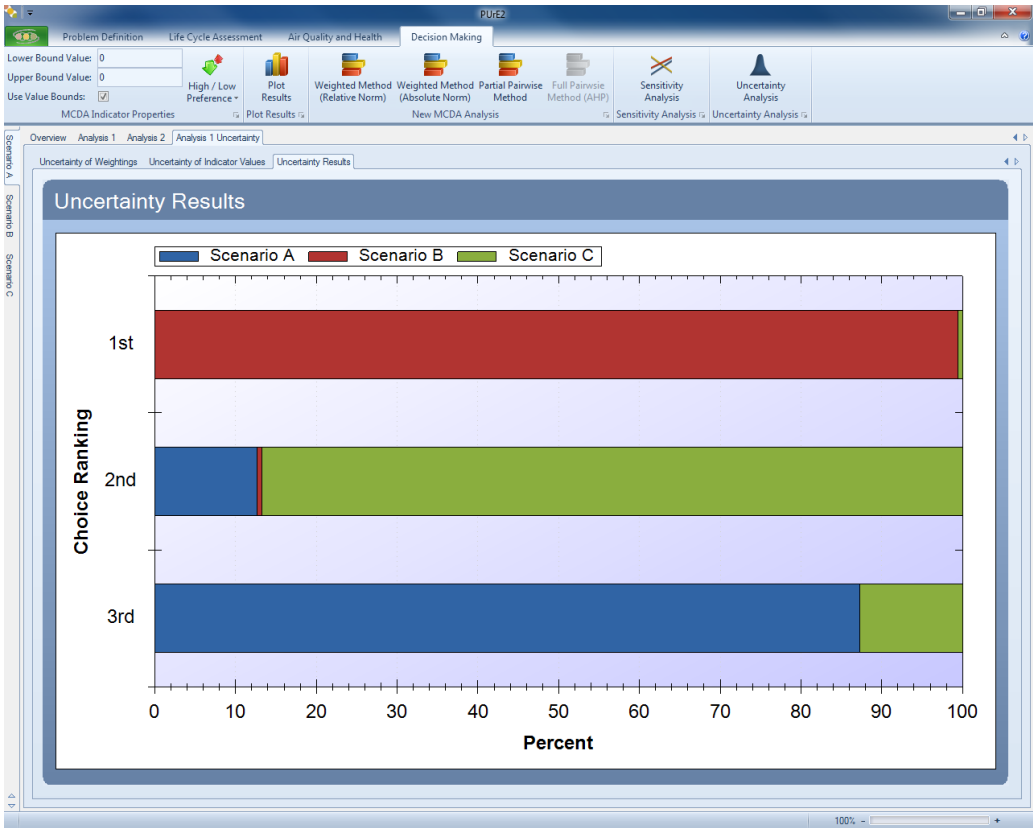
Weighted MCDA analysis



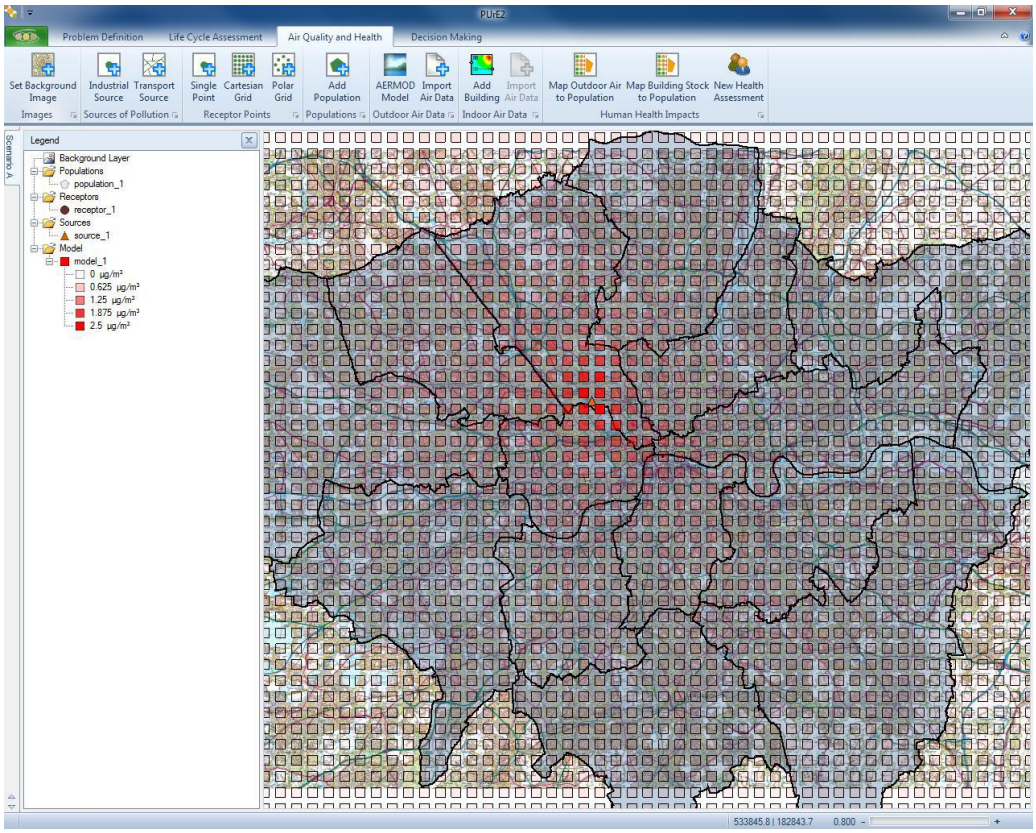
Pairwise comparisons



Sensitivity Analysis

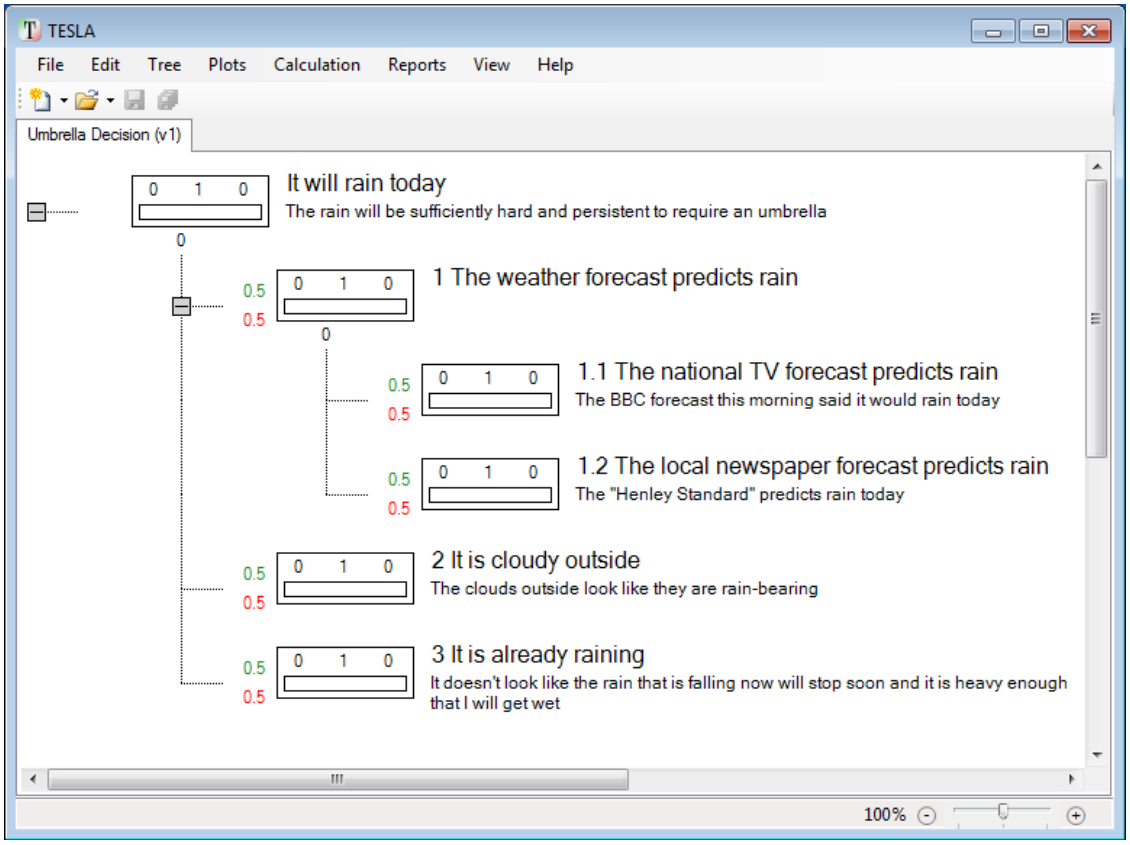


Uncertainty analysis

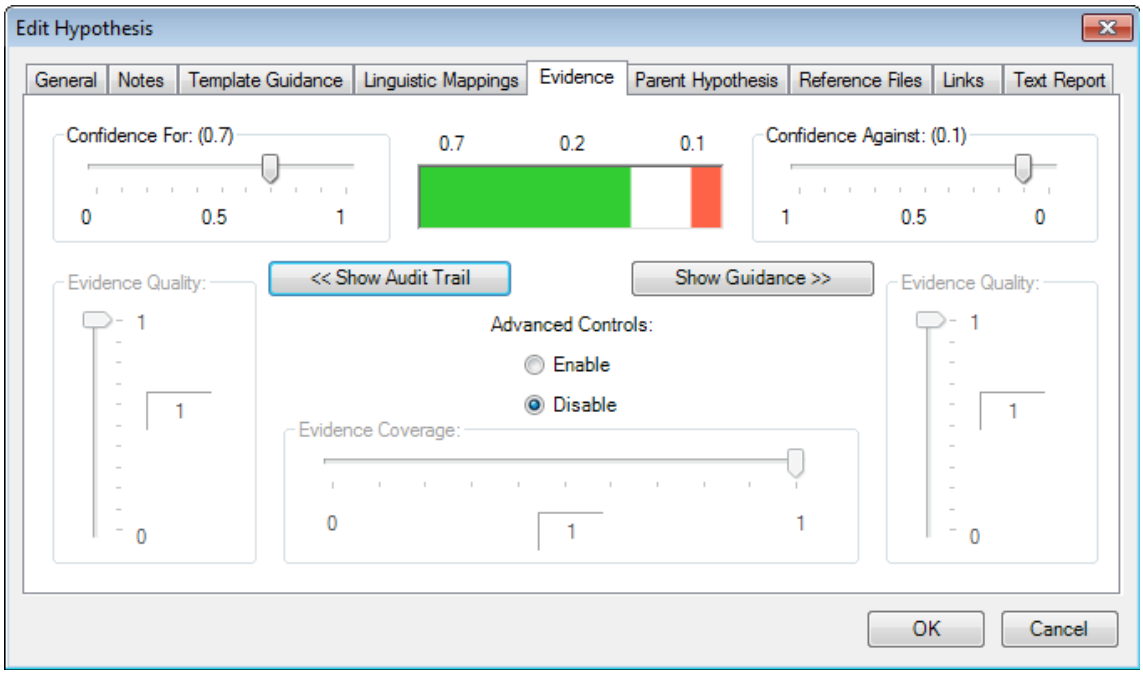


Spatial workspace

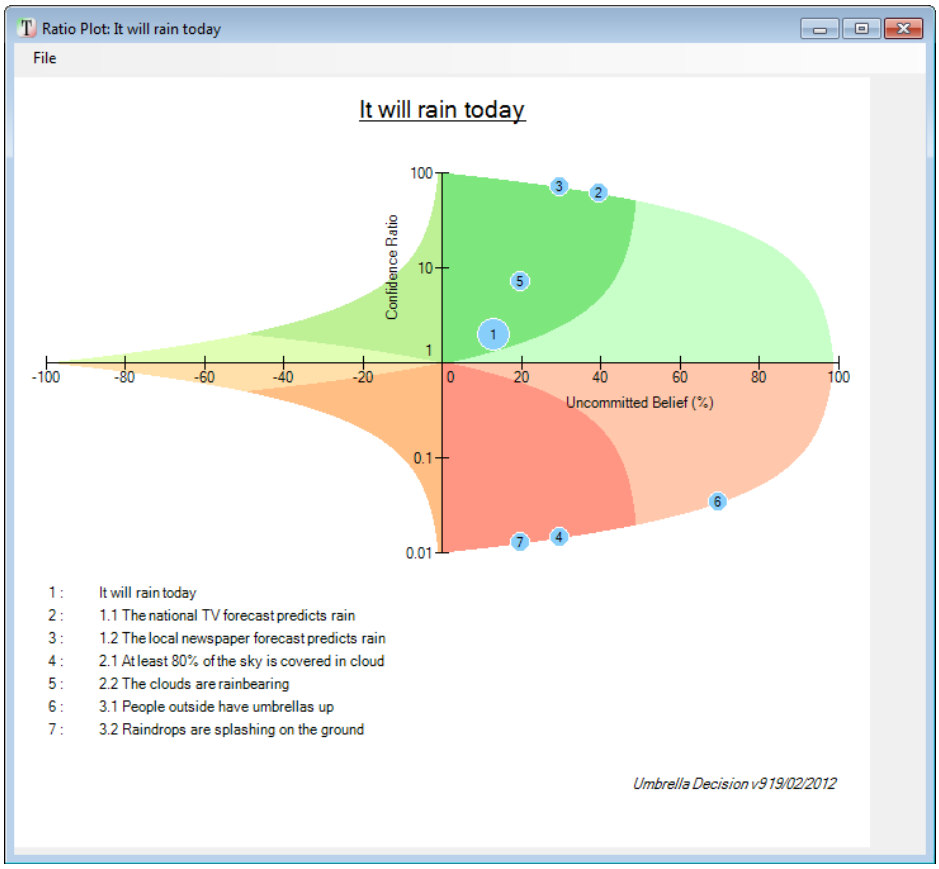
TESLA



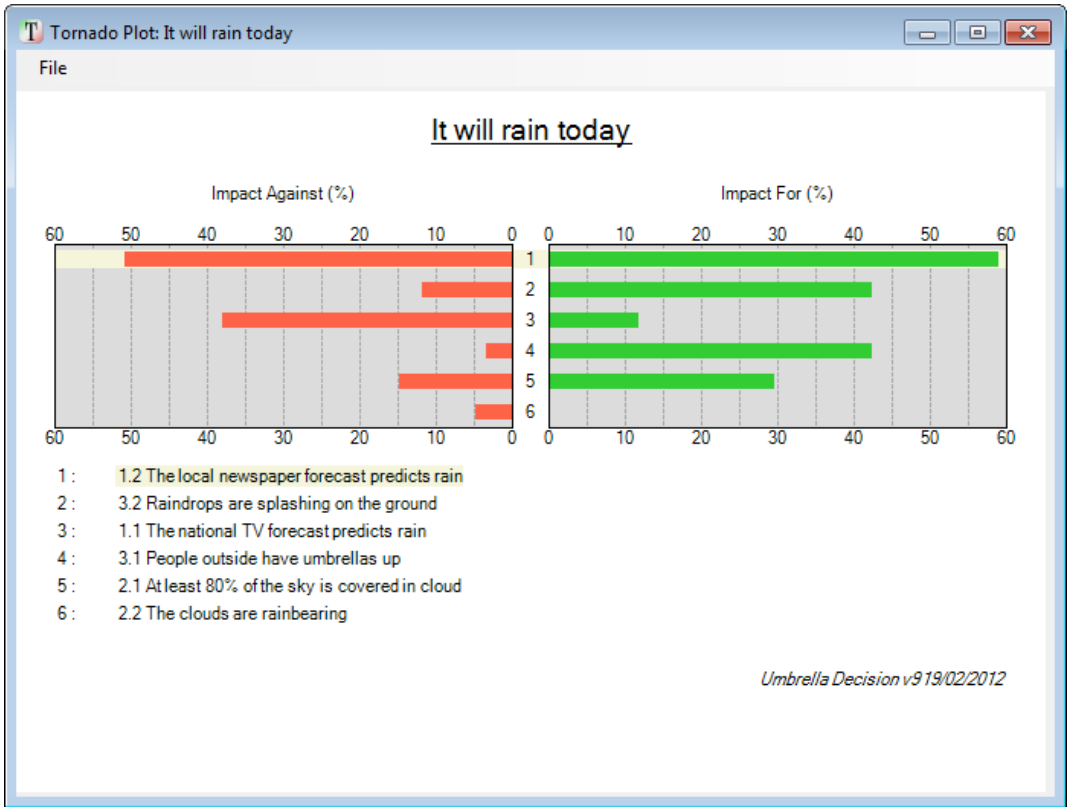
Decision tree



Confidence values



Confidence map



Tornado plot

Confidence Values

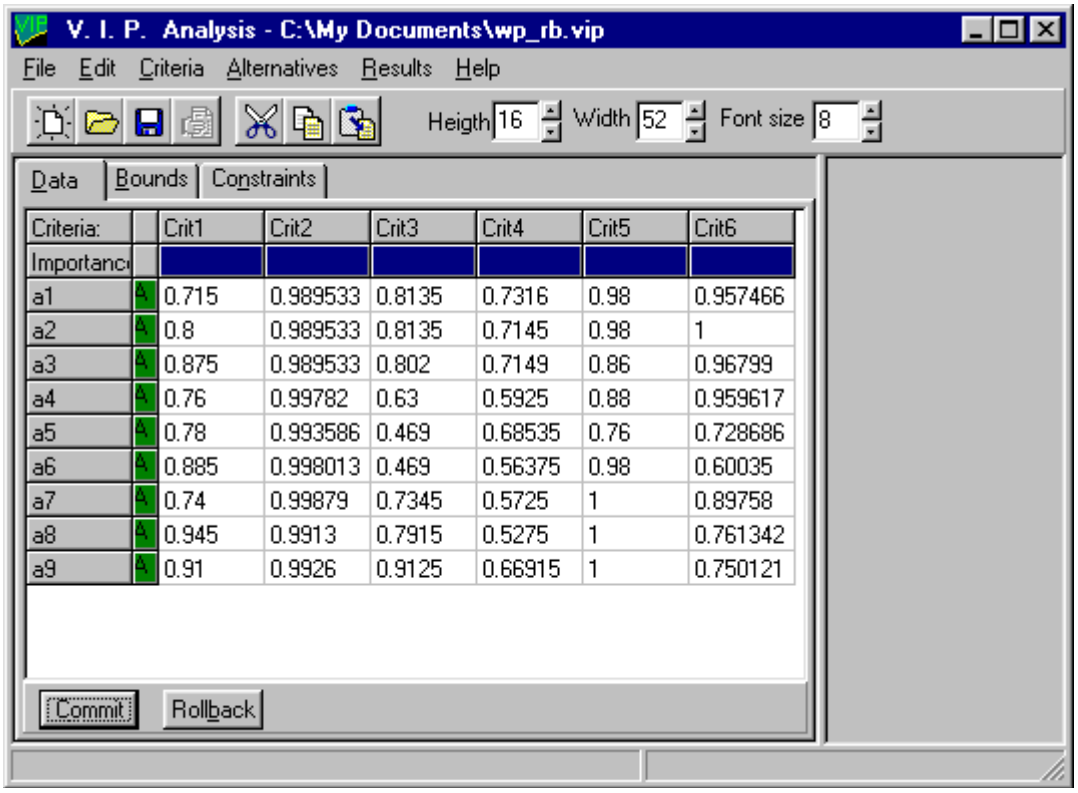
Only confidence values for leaf hypotheses (those with no children) are entered by the user. All other confidence values are calculated using the Evidence Support Logic algorithm. Values of confidence for and confidence against are listed in Table 4 for each hypothesis.

Table 4: Confidence for (supporting) and confidence against (refuting) for each hypothesis.

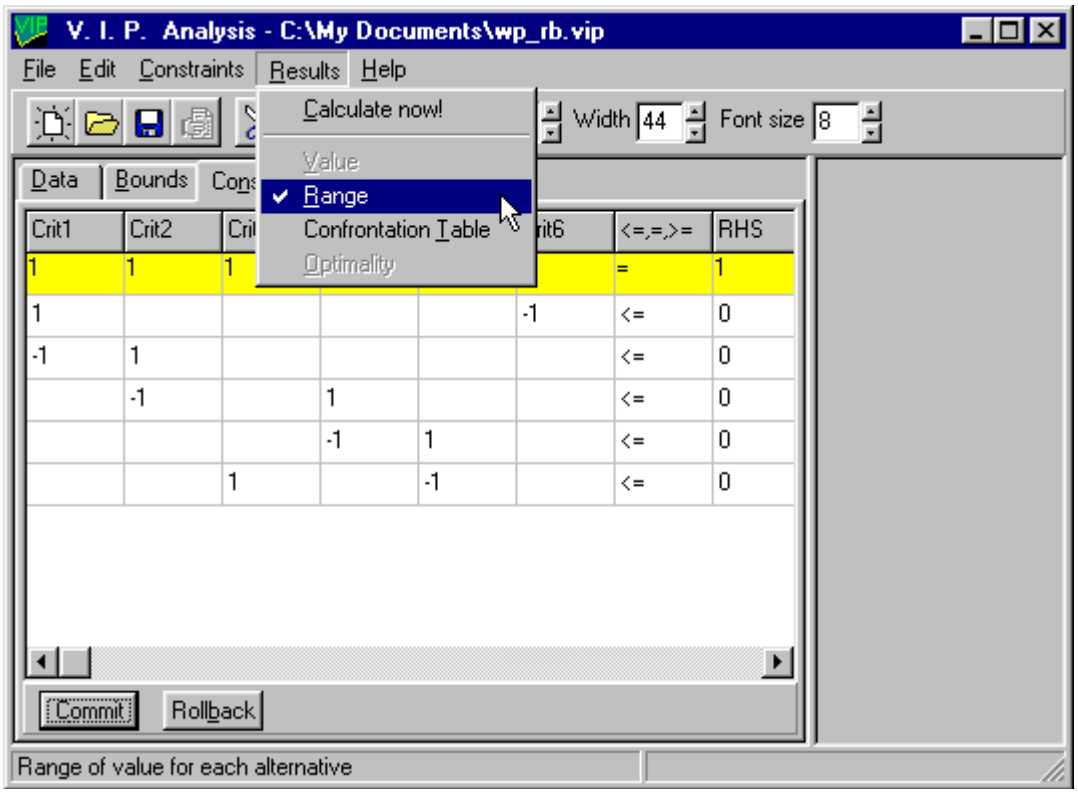
Hypothesis Name	Confidence For	Confidence Against
0 It will rain today	0.58	0.29
1 The weather forecast predicts rain	0.64	0.00
1.1 The national TV forecast predicts rain	0.60	0.00
1.2 The local newspaper forecast predicts rain	0.70	0.00
2 It is cloudy outside	0.00	0.73
2.1 At least 80% of the sky is covered in cloud	0.00	0.70
2.2 The clouds are rainbearing	0.70	0.10
3 It is already raining	0.00	0.86
3.1 People outside have umbrellas up	0.00	0.30
3.2 Raindrops are splashing on the ground	0.00	0.80

Confidence values

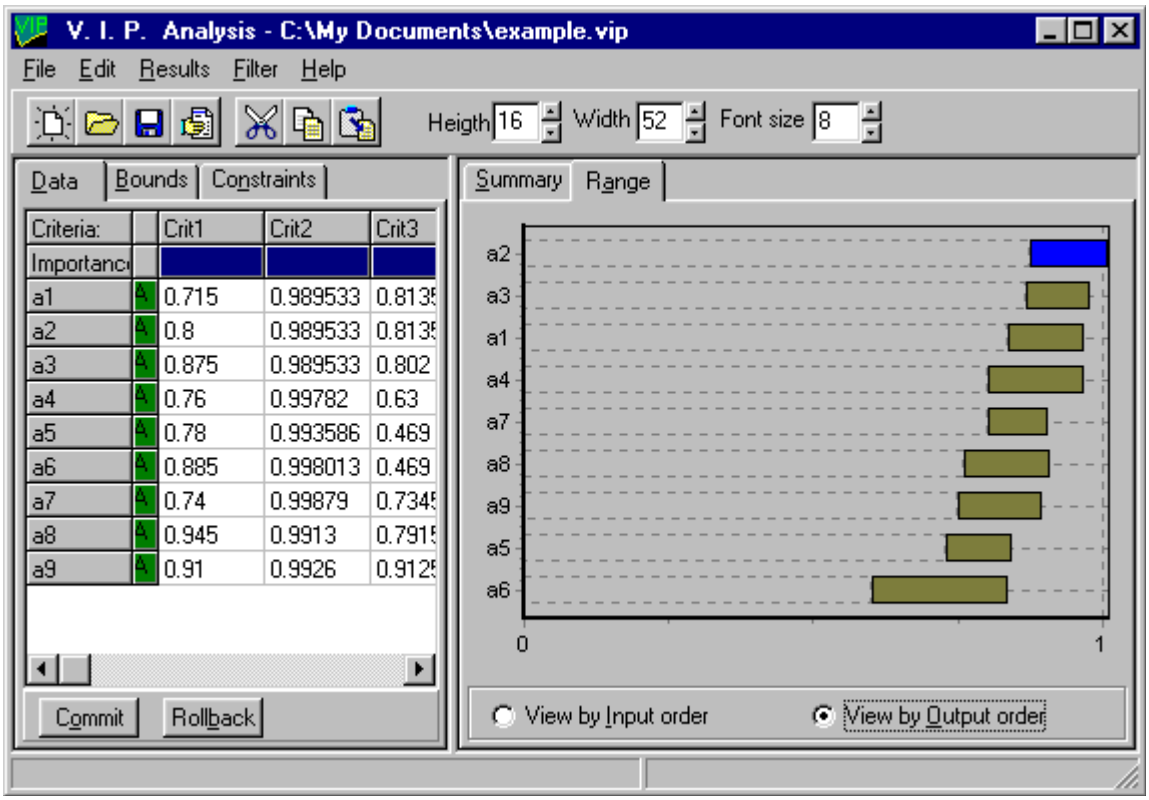
V.I.P. Analysis



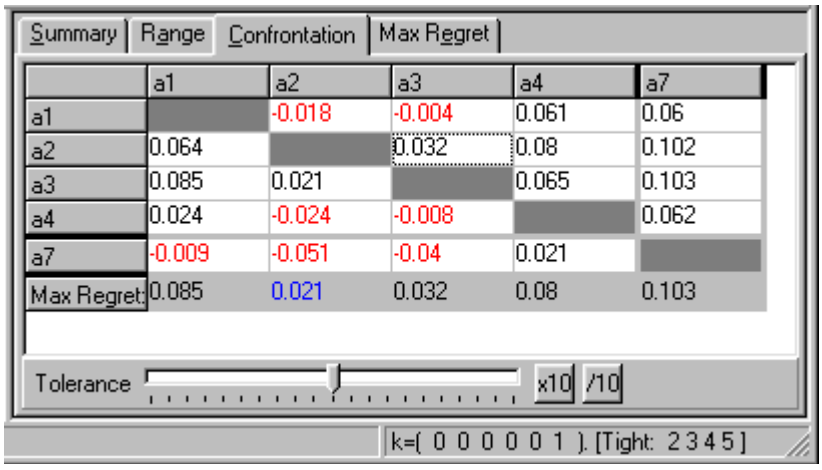
Consequences matrix



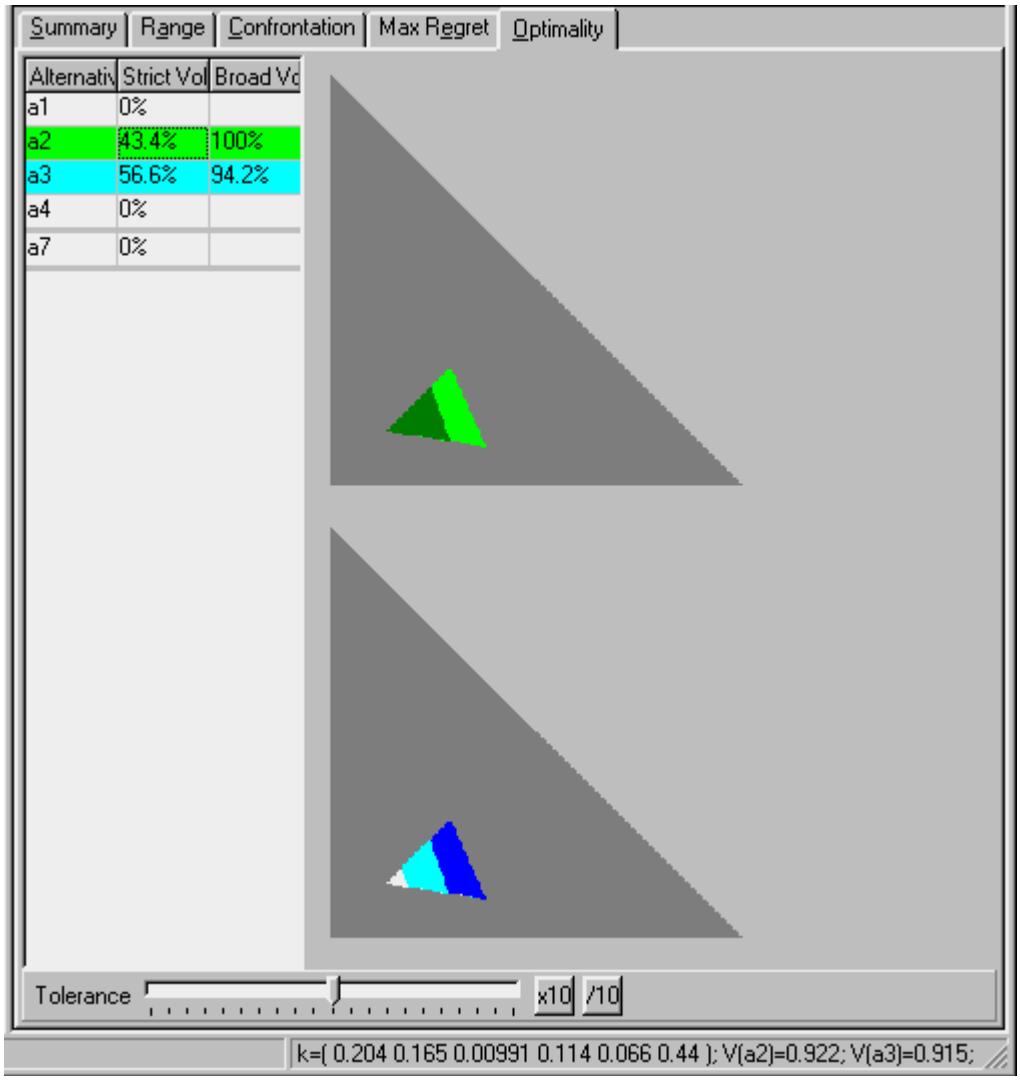
Constraints



Value intervals

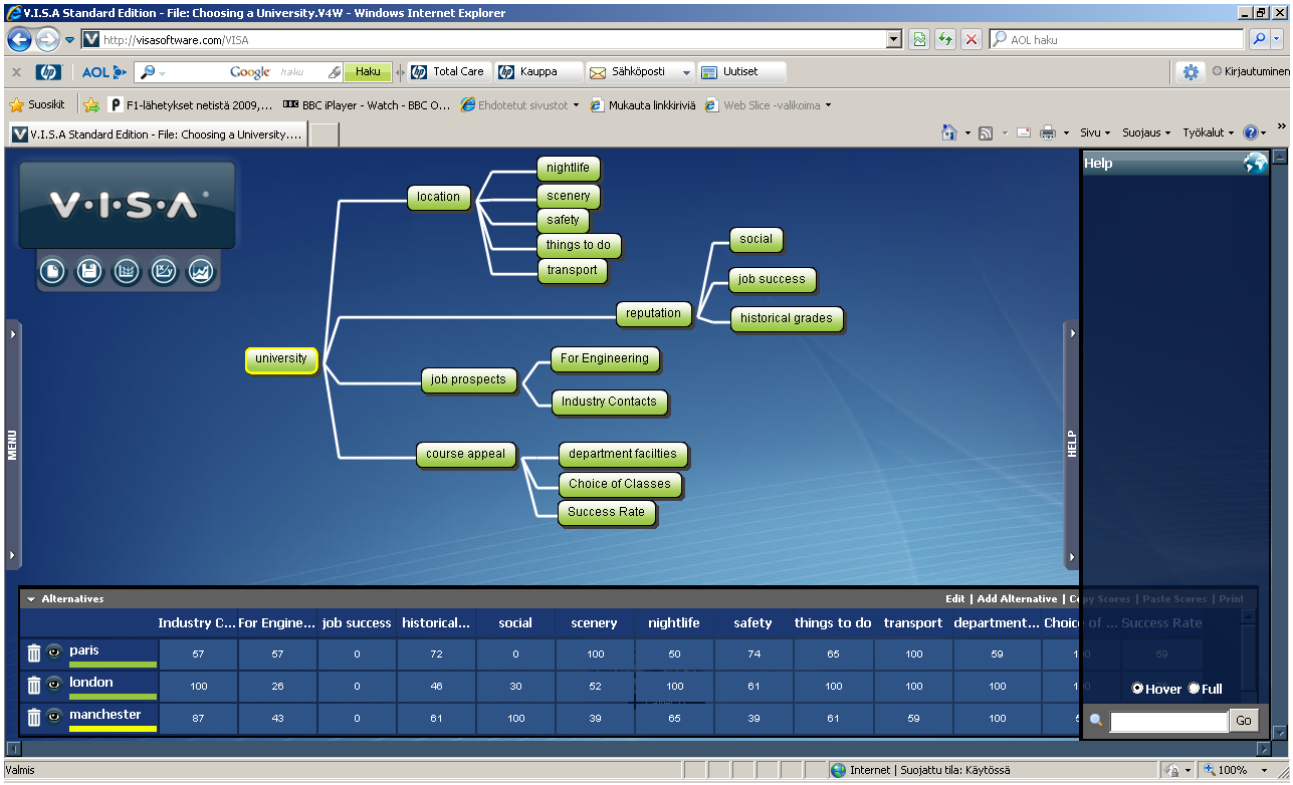


Maximum advantage of alternative compared to other ones

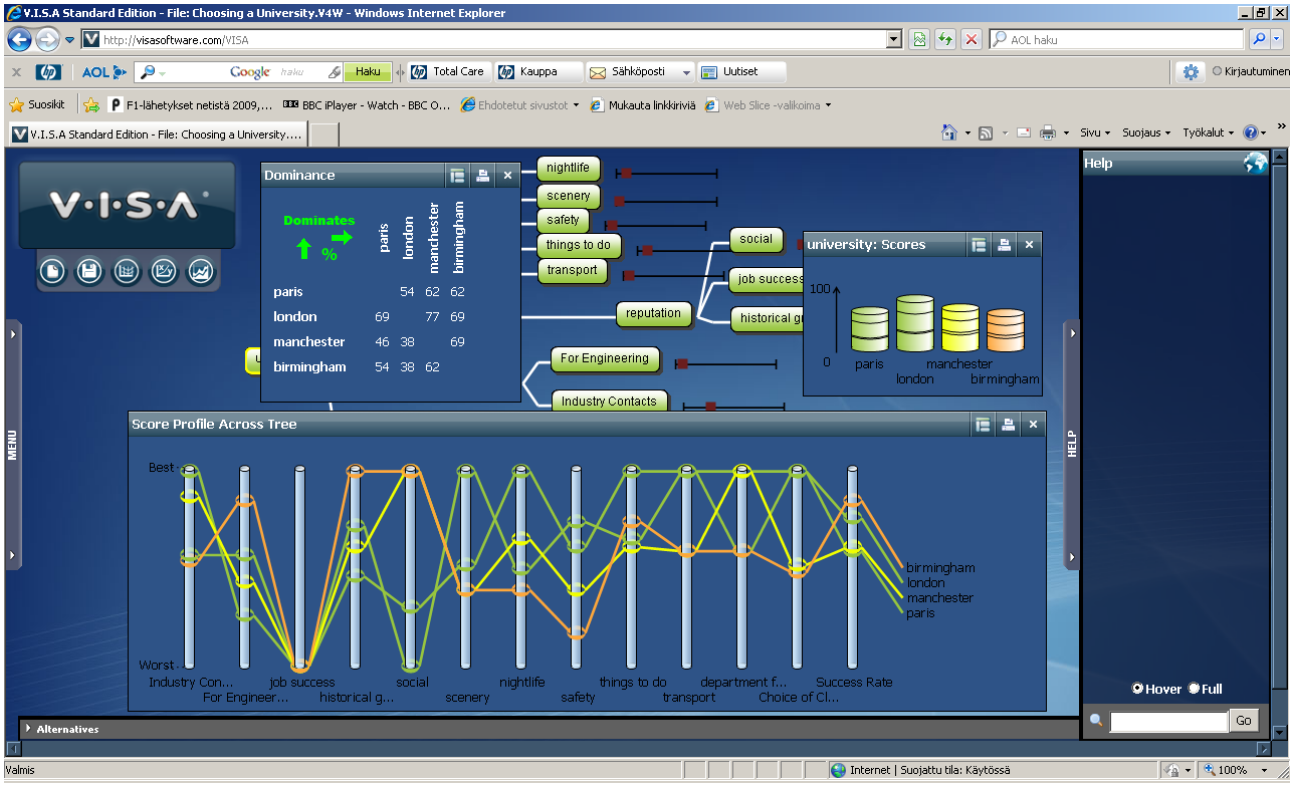


Optimality domains

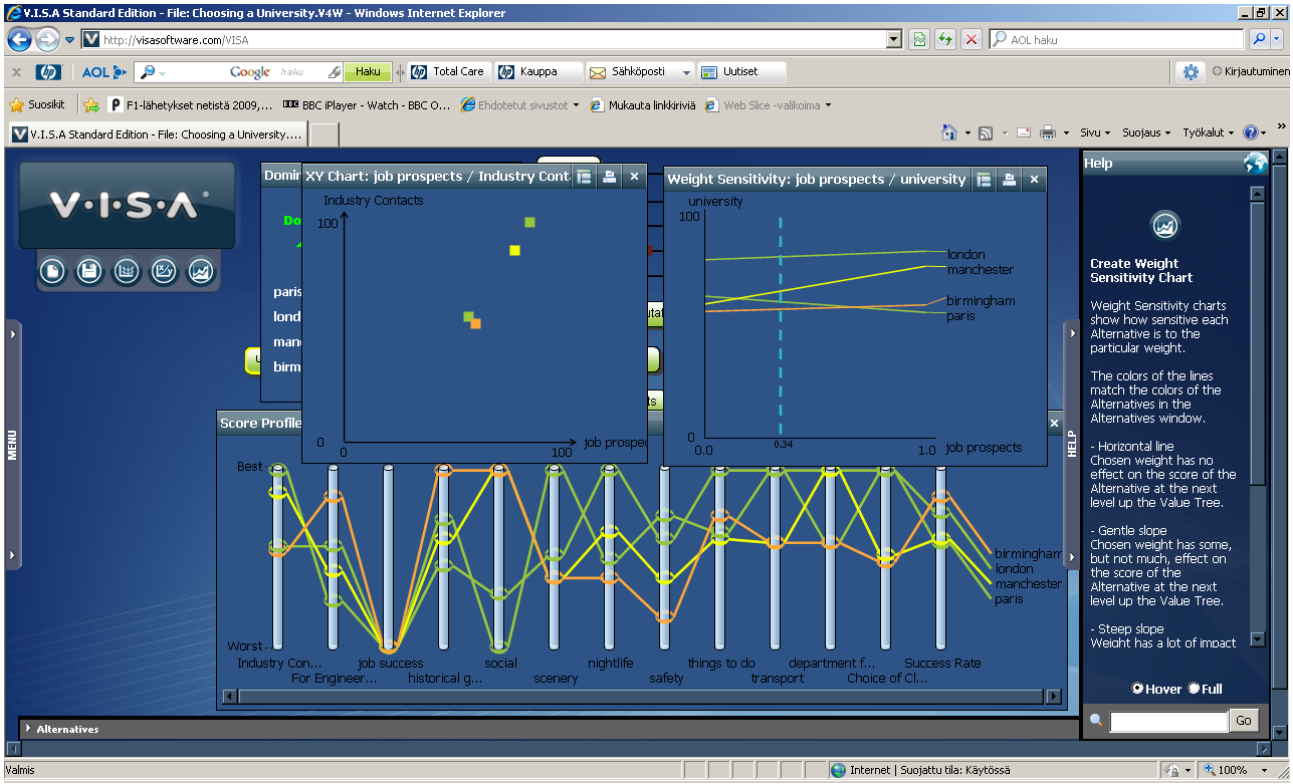
V.I.S.A.



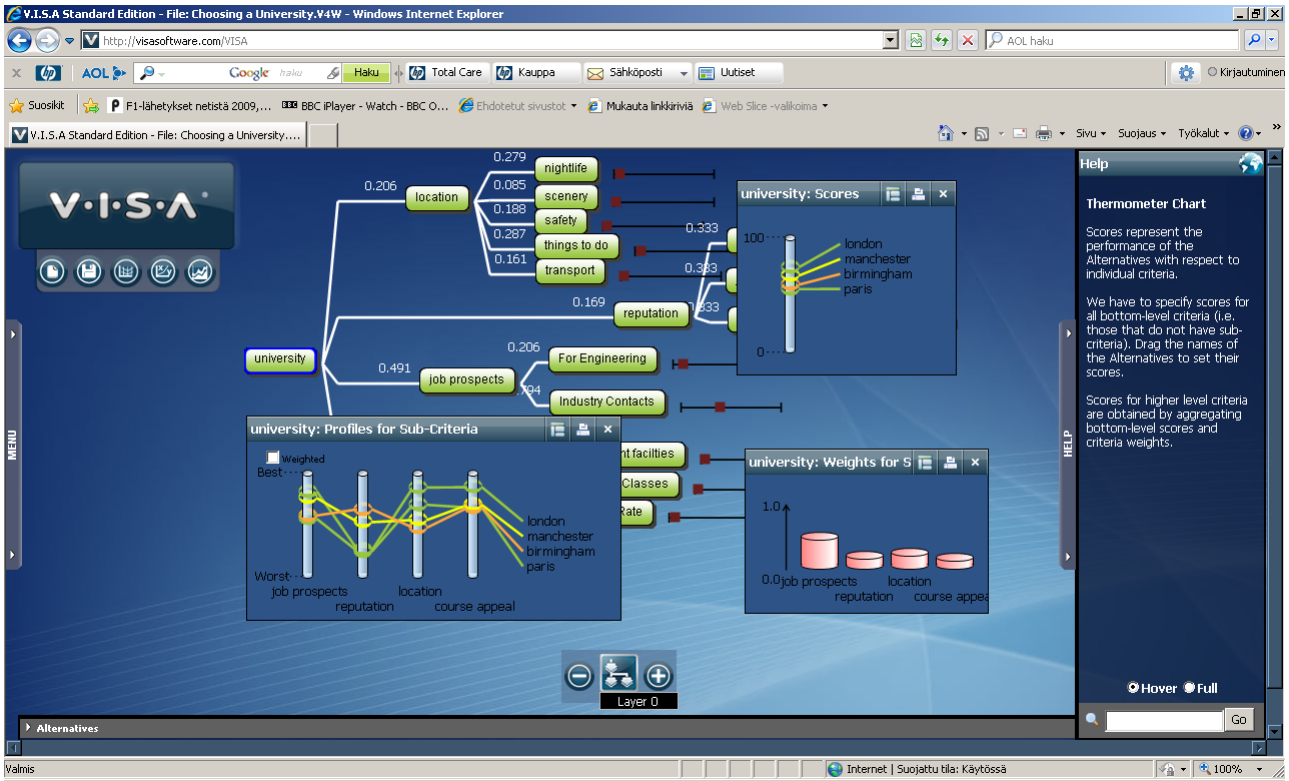
Hierarchy



Score profiles, dominance, scores

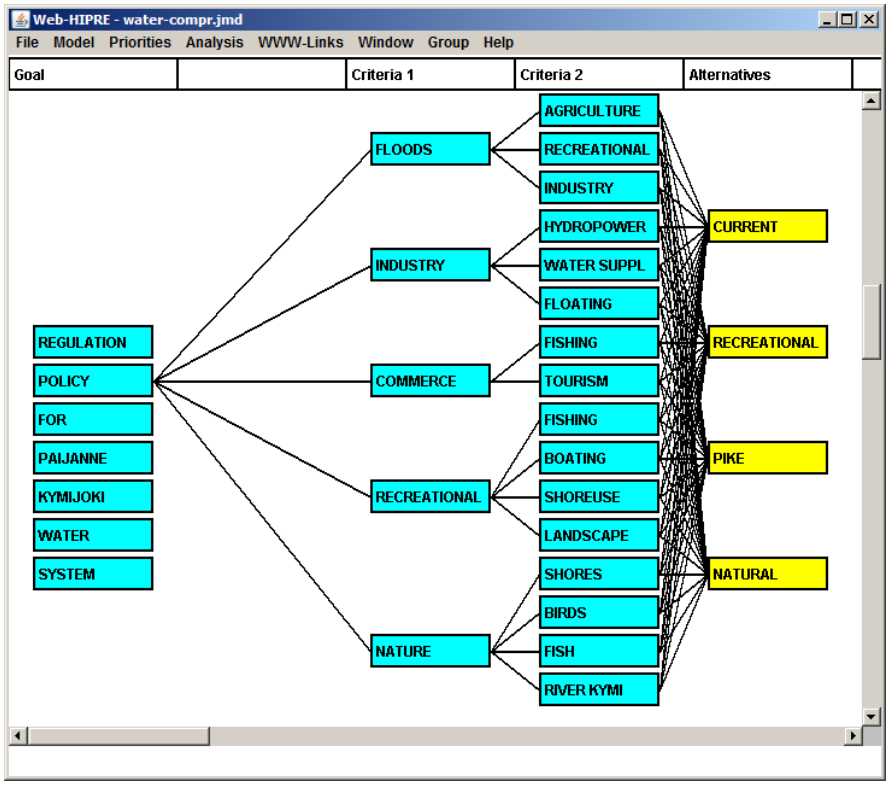


XY chart, sensitivity analysis

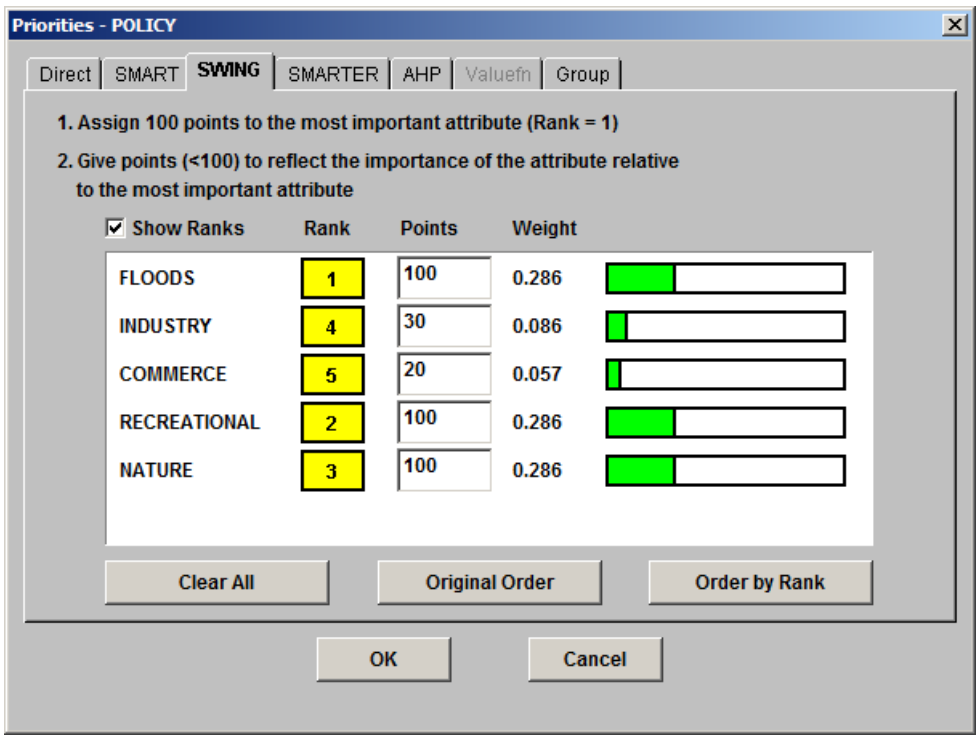


Sub-criteria profiles, weights, scores

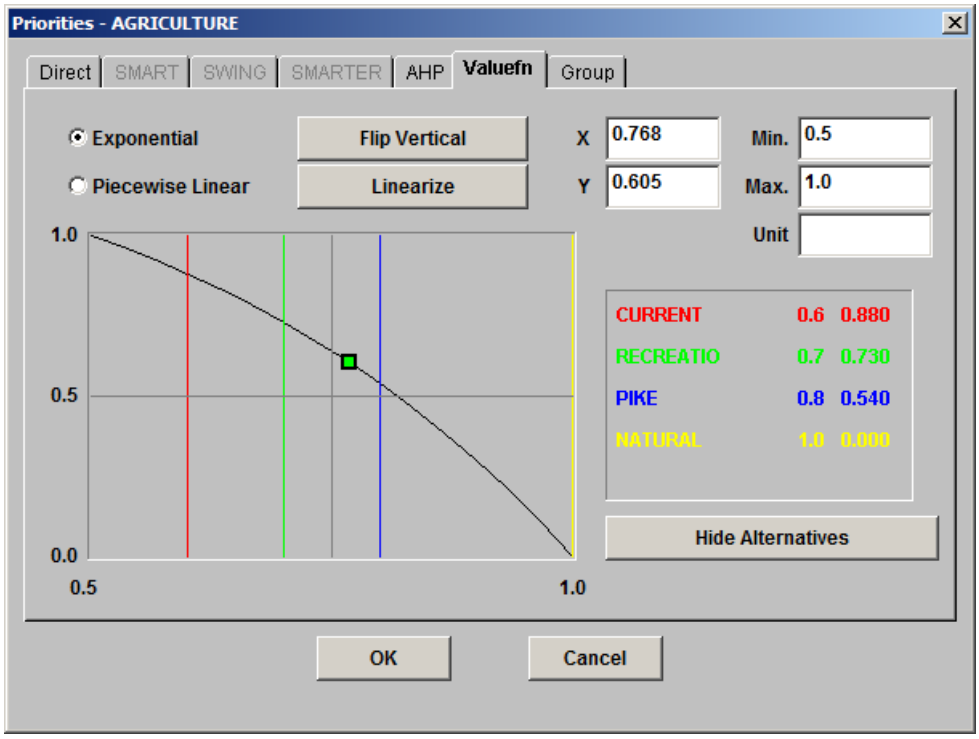
Web-HIPRE



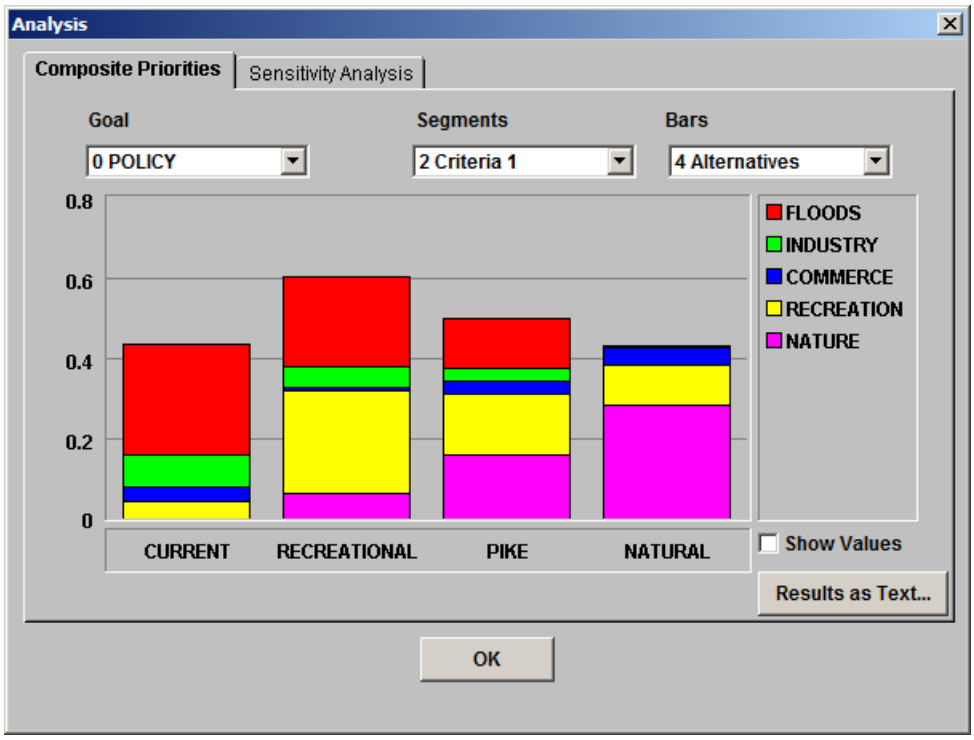
Value tree



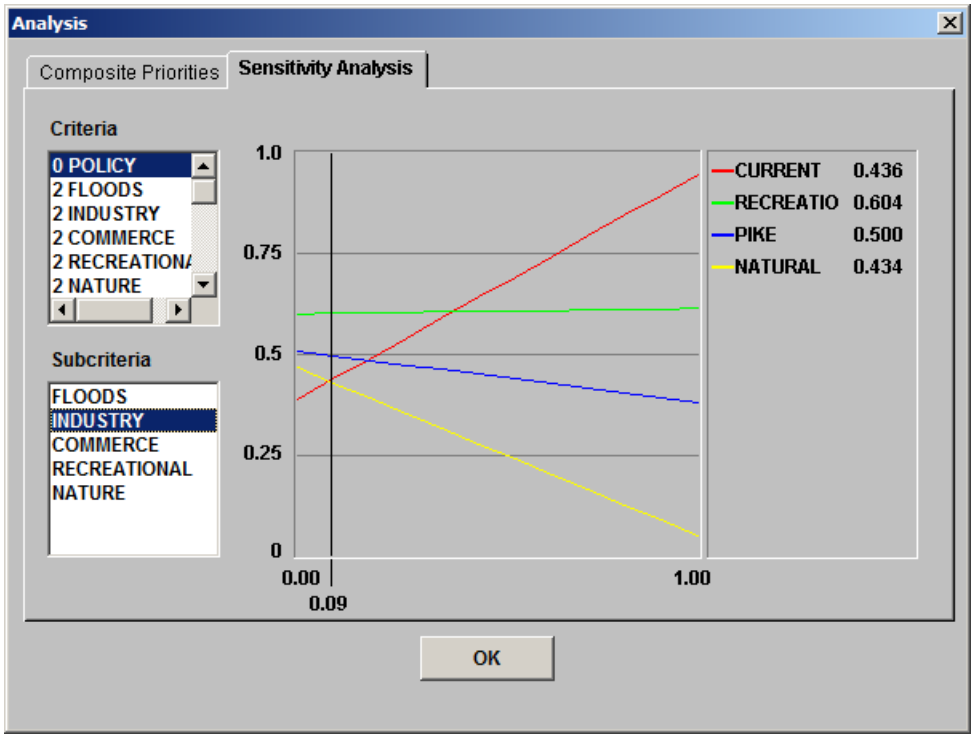
Swing weighting



Value Function

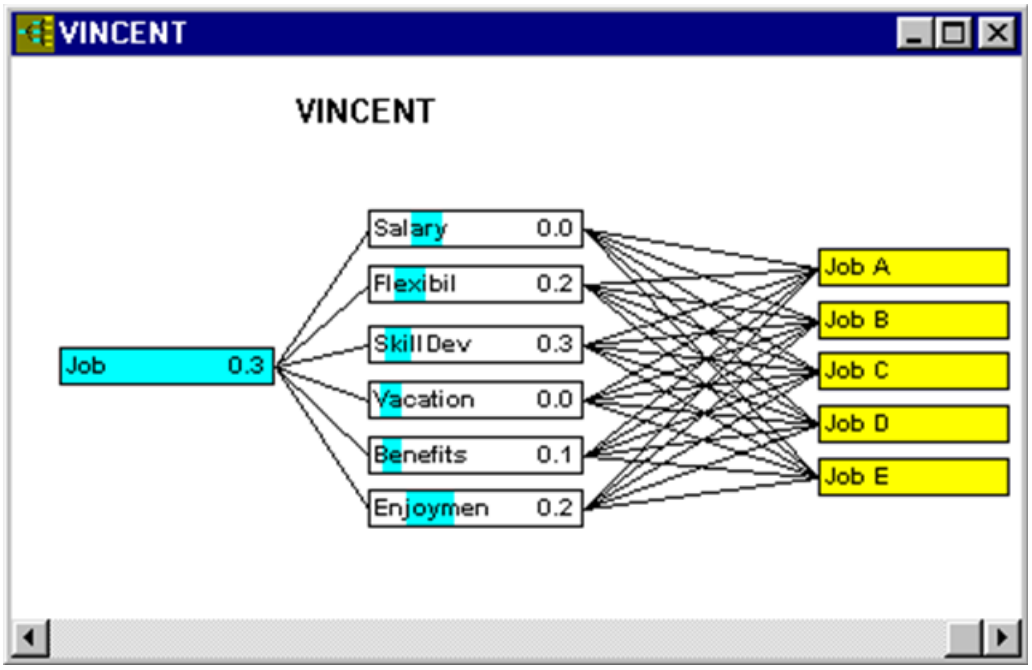


Composite priorities

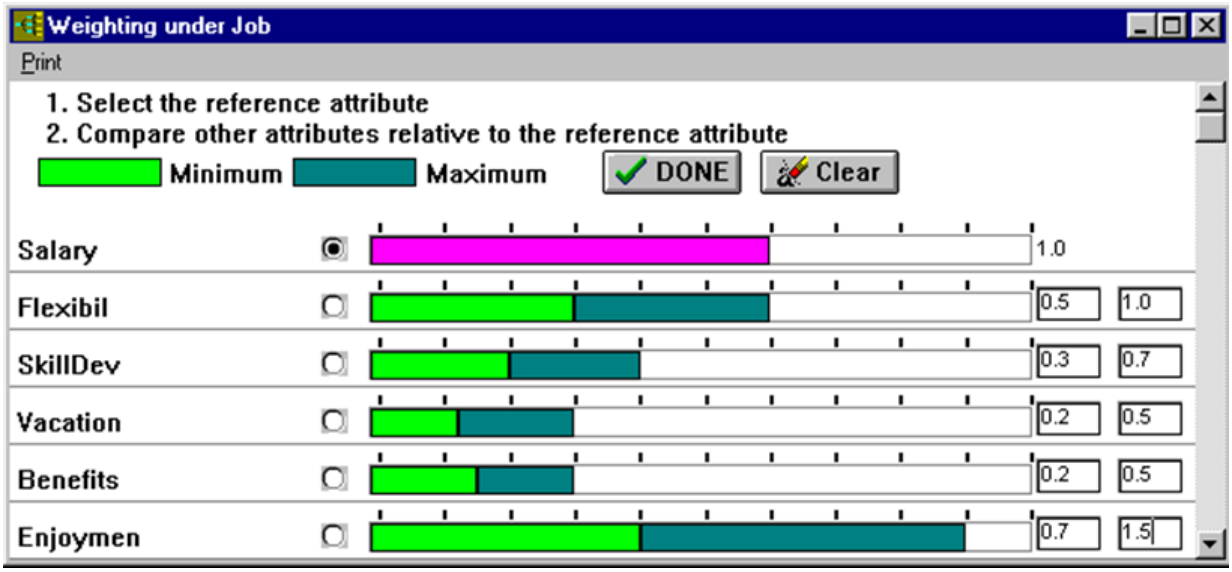


Sensitivity analysis

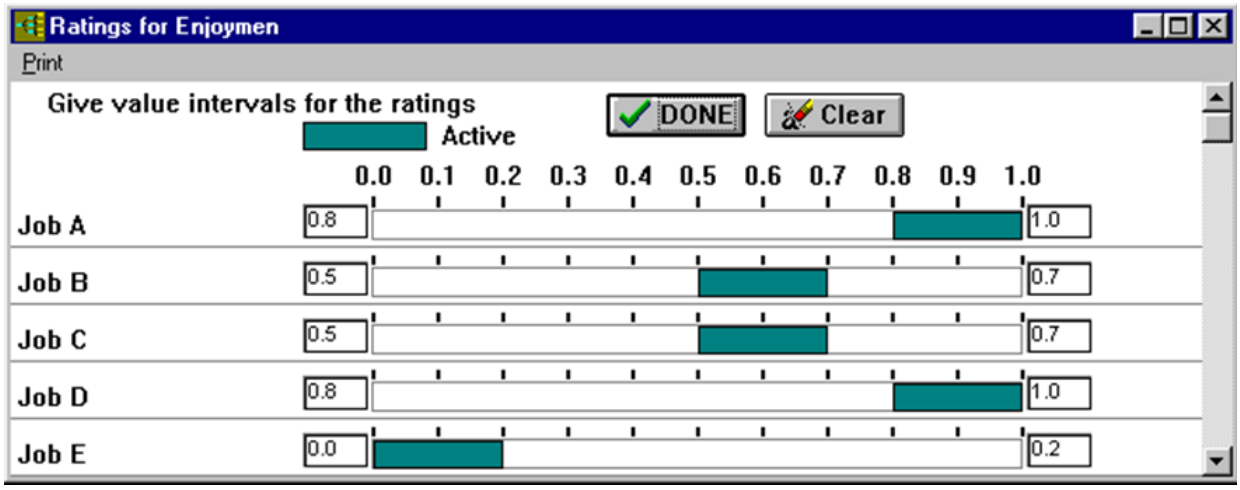
WINPRE



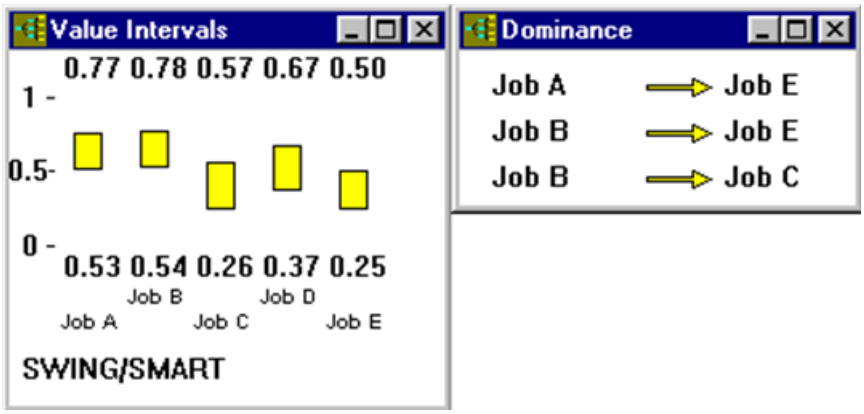
Value tree



Interval-SMART/SWING



Ratings



Results - Value intervals and dominance relations