SOFTWARE ANNOUNCEMENT: MULTICHOICE AS NEW SOFTWARE FOR DECISION MAKING WITH ANALYTIC NETWORK PROCESS [1]

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ABSTRACT

This paper describes the main features of Multichoice, a new version of software for multi-criteria decision analysis with ANP/AHP. Multichoice has been developed by authors at the Central Institute of Economics and Mathematics of the Russian Academy of Science in Moscow in 2016, and is the first software for ANP in Russia (available in Russian and English). The paper outlines the main steps of ANP technology: model constructing, relative and absolute evaluating, synthesizing, visualizing and importing the results, and sensitivity analysis. The authors also discuss further development of implementation of ANP-algorithms.

Keywords: software development; Analytic Network Process; Analytic Hierarchy Process; decision-making; Multichoice

1. Introduction

The appropriate software is invaluable in modern decision-making. Nowadays, there are many programs based on the Analytic Hierarchy Process (AHP) on the software market. Generally, they can be divided into three types: independent software, add-ins for Microsoft Excel, and online calculators. Some of them are trivial and permit working with very simple structures; others allow one to deal with complex problems and give many opportunities to decision-makers. This variety allows the appropriate software to be chosen depending on the user's goal. Actually many decision problems cannot be structured hierarchically because they involve interaction and dependence between elements. Thus, to deal with real life problems we should apply the Analytic Network Process (ANP) – a generalization of AHP. ANP allows both interaction and feedback,

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which best captures the complex effects of interplay in human society, especially when risk and uncertainty are involved.

Worthy implementation of ANP is much more complex than implementation of AHP, so there is only one version of software for ANP applications available on the market today. This is the Super Decisions software, written by the ANP Team, working for the Creative Decisions Foundation. The SuperDecisions software is available for free (www.superdecisions.com/~saaty) on the internet (Saaty, 2009).

Because one of our key interests includes the area of decision making associated with ANP, we have tried to develop an ANP technology through creating a new version of software that meets all requirements related to modern decision making.

It is with respect to the author of ANP/AHP, Dr. Saaty and his team, that we have created the Multichoice software as an instrument, where we can implement all things we faced in the ANP: model constructing, relative and absolute evaluating, synthesizing, visualizing and importing the results, sensitivity analysis.

In this paper, we discuss the main features of the Multichoice software, and propose further development of implementation of ANP-algorithms. We will not focus on the theory of ANP/AHP, assuming that readers are familiar with its concept.

2. Multichoice overview

2.1 Base principles

Multichoice is a new software product created to support multi-criteria decision analysis based on the ANP/AHP. The Multichoice software has been developed by authors at the Central Institute of Economics and Mathematics of the Russian Academy of Science, in Moscow in 2016, and is the first software for ANP in Russia. The software is certificated by the Russian Federal Service for Intellectual Property.

Multichoice software is based on the following concepts:

- User friendly interface
- Common workspace for all networks and hierarchies for the model
- Distinct tool kits for network and hierarchy
- Handy instruments for data export and visualization
- Opportunity for expanding software functionality
- Russian and English software version

Multichoice has been tested in the educational process by solving different decision-making problems (Andreichikova, Milkova, 2016).

Further, we describe the main steps of ANP/AHP technology realized in the first version of the Multichoice software.

2.2 Model construction

The first step of decision making is specifying the decision problem and constructing the structures to represent the problem.

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Thus, at the start window of Multichoice the main goal and the base structure of the model are defined: networks (or hierarchies) under control hierarchy or a single network (or hierarchy). Further, one can specify all its elements (subnetworks, clusters, nodes, and relations between them) at the main window.

The main window contains workspace, a menu, the area with the model structure to navigate, and an area for any comments to specify the network (hierarchy), cluster or node (see Figures 1 and 2).

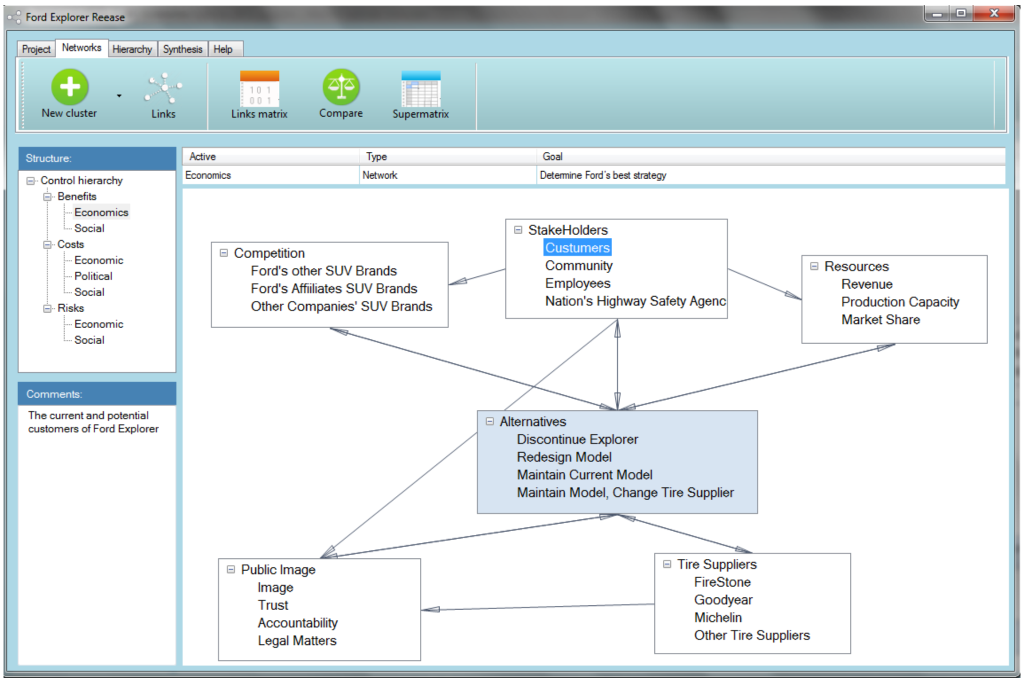

Figure 1. Main window of Multichoice: network

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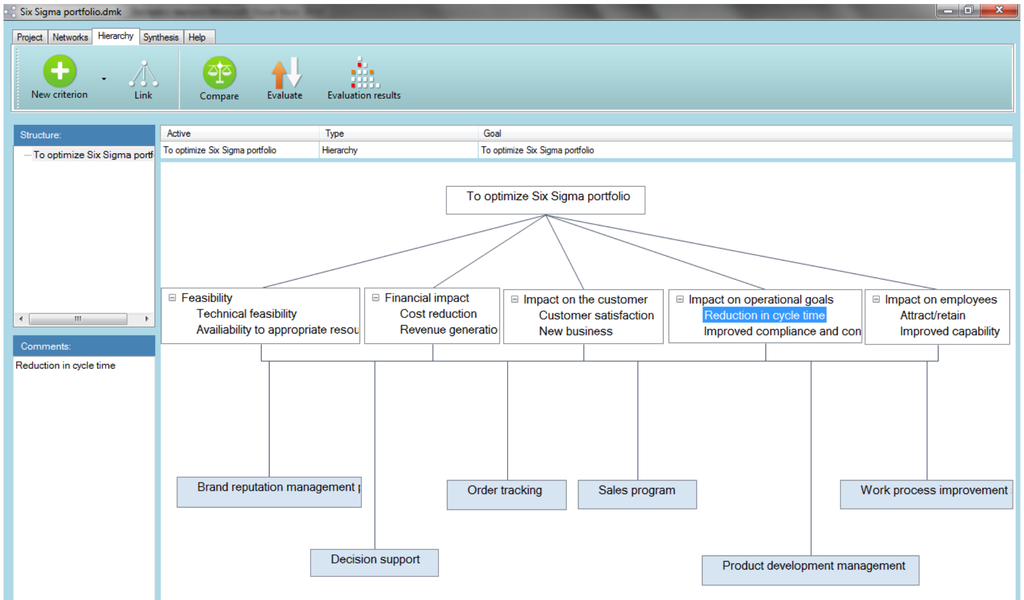

Figure 2. Main window of Multichoice: hierarchy

Network and hierarchy have different diagrams. Hierarchy looks like the straight hierarchy structure with the main goal at the top and levels arranged in a descending order of importance (see Fig 2). In a network, the components are not arranged in any particular order, but are connected as appropriate in pairs with directed lines – arrows, forming loops if the element has connection with itself (see Figure 1).

Depending on whether the network or hierarchy is defined as a problem structure, the appropriate menu tab is activated (see also Figures 1 and 2). The tab for networks contains options for creating connections, displaying matrices of connections, a supermatrix and its limit forms, and limit vectors. The tab for hierarchy is simpler and does not have these options.

2.3 Evaluating

Multichoice software permits the use of a relative or absolute type of evaluation for expert's judgments. Relative judgment is performed by paired comparisons of elements according to which element influences a third element more and how strongly more with respect to a control criterion (Saaty, 2013). The first version of Multichoice has been developed for researchers only, so we have not included visual types of evaluation, questionnaires and provide the main form of elements evaluation – the comparison matrix. These can be added into future versions, as could the possibility for setting the priority vector directly.

Screenshots for pairwise comparisons of the elements within a network are shown in the Figures 3 and 4.

The panel for navigation through all comparison matrices is arranged at the left of the screen. A checkbox near the comparison matrix shows if the matrix is consistent. An appropriate consistency ratio (CR) for the model is set in the box "Limit value of C.R."

by an expert and must be less than 0.2. If the CR for any matrix is higher than the given limit value, Multichoice will not calculate the supermatrix of the network.

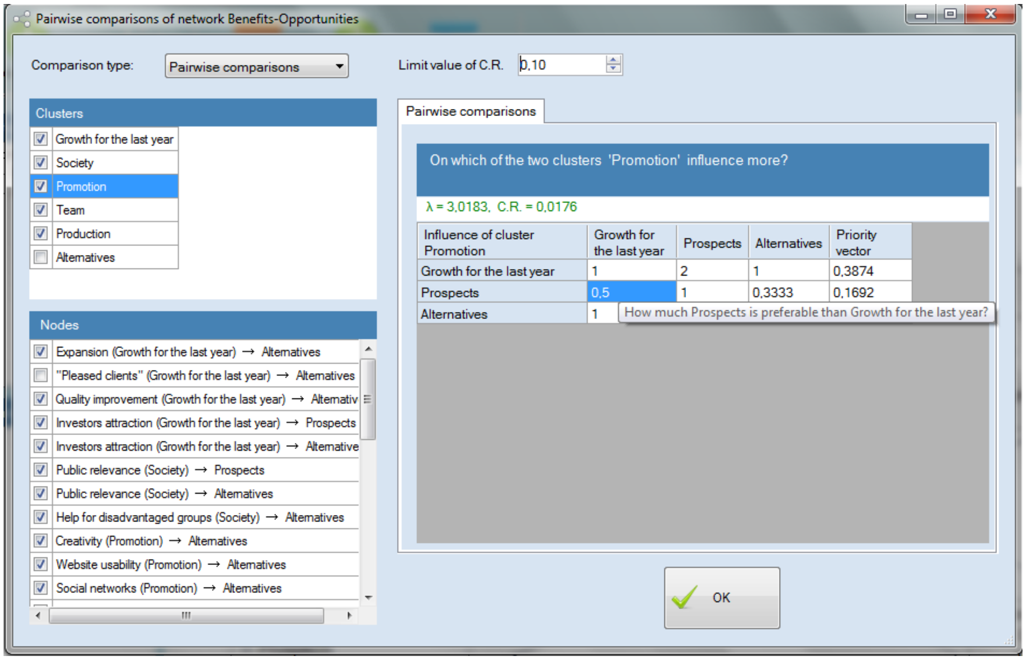

Figure 3. Pairwise comparisons: cluster comparisons

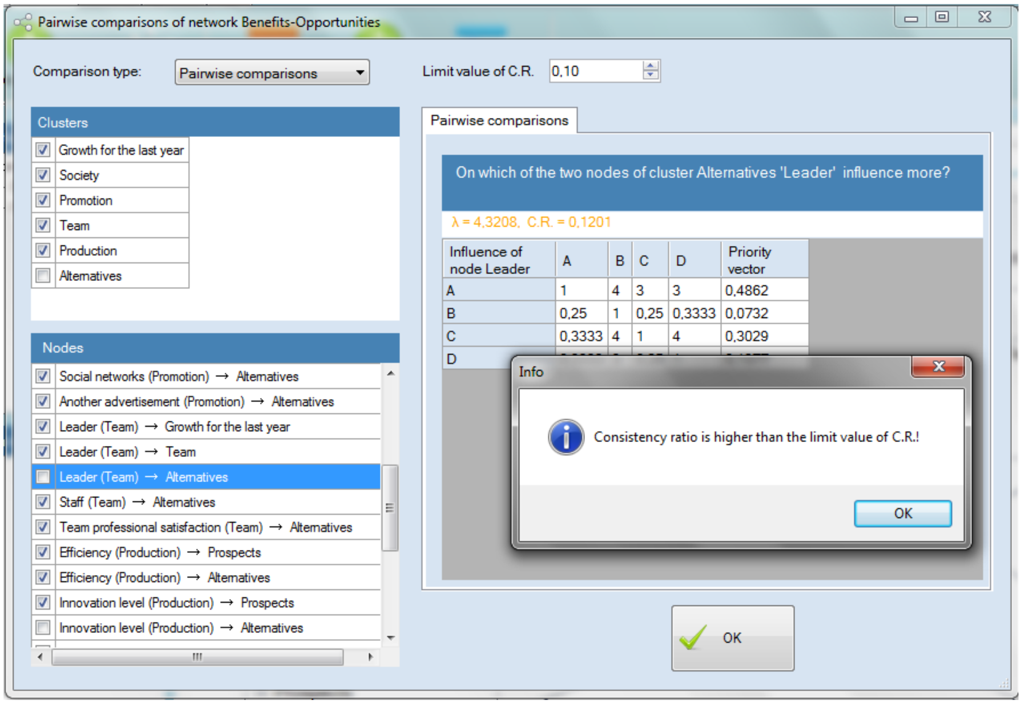

Figure 4. Pairwise comparisons: nodes comparisons

Absolute judgment is performed by establishing rating categories for each covering criterion (see Figure 5).

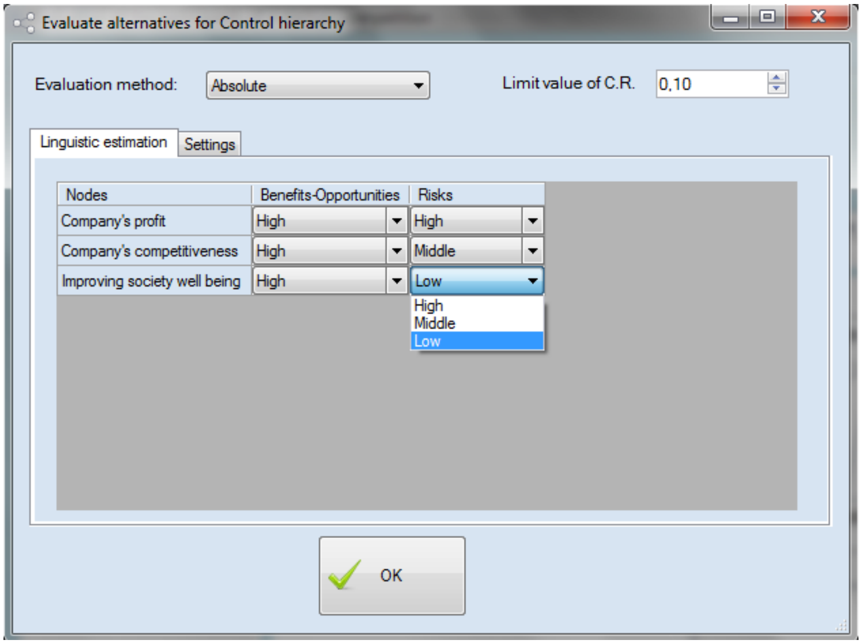

Figure 5. Alternatives absolute evaluation

Elements are evaluated by assigning the appropriate rating category for each criterion. In Multichoice, by default, there are the following rating categories: “Very high”, “High”, “Middle”, “Low”, “Very low”. Categories are prioritized by pairwise comparing them for preference (see Figure 6).

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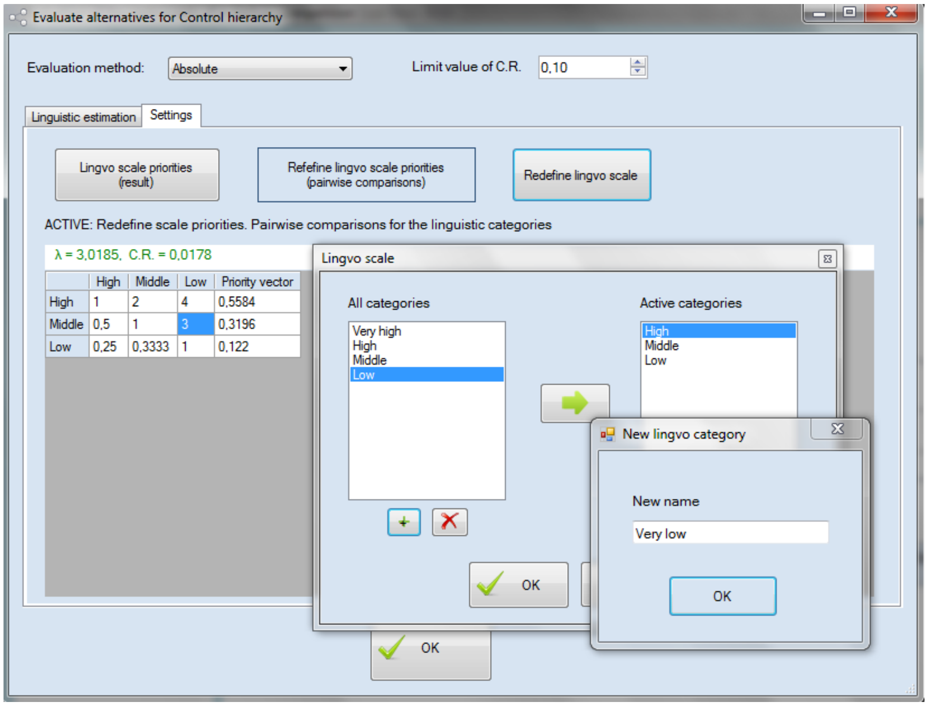

Figure 6. Linguistic scale settings

2.4 Obtaining results

Priorities of network nodes derived from the paired comparisons form the columns of the supermatrix (see Figure 7).

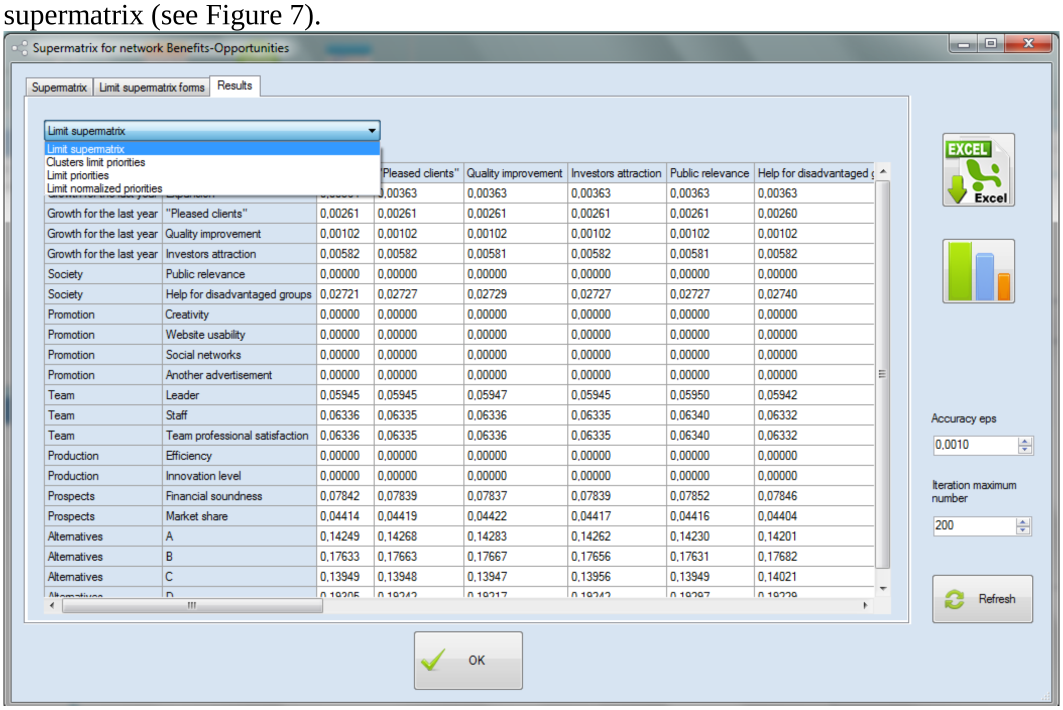

Figure 7. Limit Supermatrix

Cluster's priorities are used to weight the elements of the corresponding column blocks of the supermatrix. Limit priorities are computed in the limit supermatrix. Limit priority vector, normalized by cluster priority vector and limit priority vector for clusters are also shown in the Multichoice window for supermatrices. All results can be quickly exported to MS Excel.

Any results may be visualized by a column chart (see Figures 8 and 9) and then saved to *.png format.

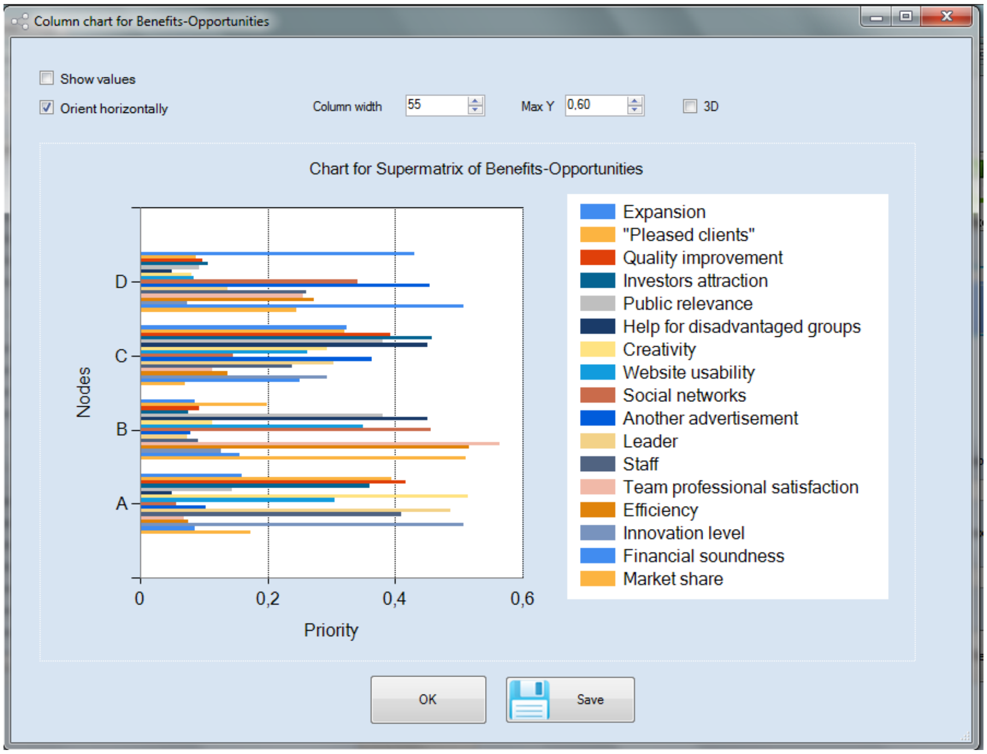

Figure 8. Chart for the results: multiple column charts for Supermatrix

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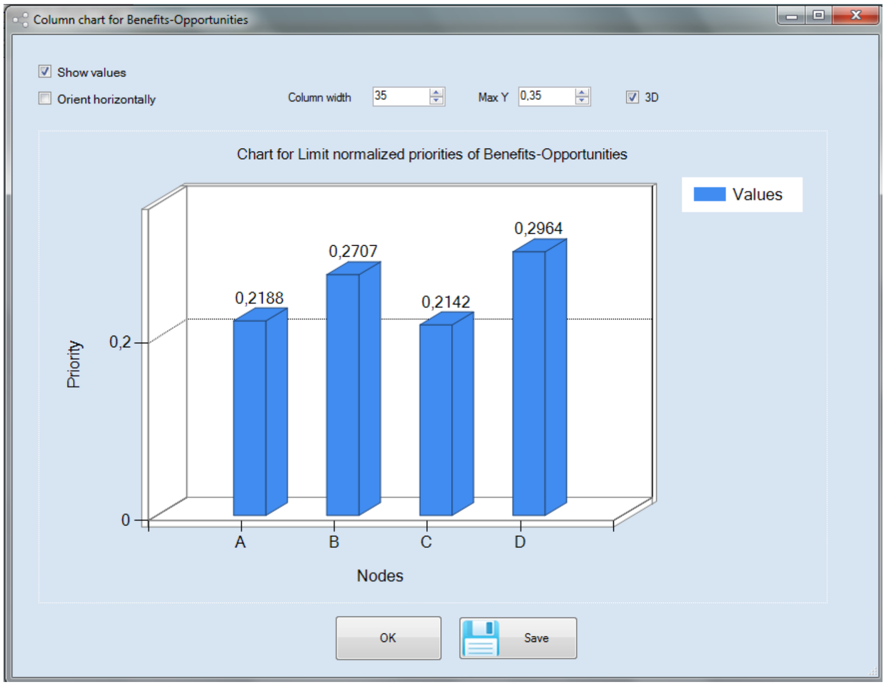


Figure 9. Chart for the results: 3D-column chart for limit normalized priorities

To synthesize the results we select networks whose priorities should be inverted (or select nothing if there are no priorities to invert) and then obtain the results with additive and multiplicative types of composition. In Multichoice we use the following formulas to obtain the results (for BOCR model):

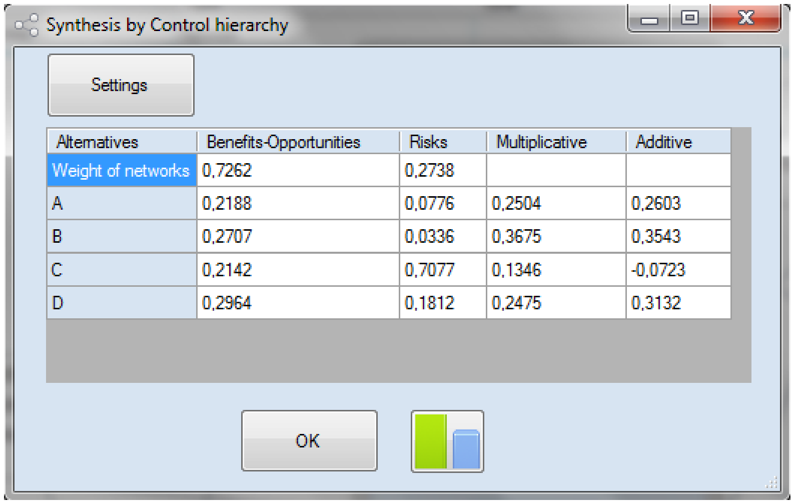
$$F_{A_i}^{MULT} = \frac{(P_{A_i}^{B})^{w_B} \cdot (P_{A_i}^{O})^{w_O}}{(P_{A_i}^{C})^{w_C} \cdot (P_{A_i}^{R})^{w_R}} \quad (1)$$

$$F_{A_i}^{MULT} = \frac{(P_{A_i}^{B})^{w_B} \cdot (P_{A_i}^{O})^{w_O}}{(P_{A_i}^{C})^{w_C} \cdot (P_{A_i}^{R})^{w_R}}, \quad (2)$$

where $P_{A_i}^{B}, P_{A_i}^{O}, P_{A_i}^{C}, P_{A_i}^{R}$ – priorities of A_i in Benefits, Opportunities, Costs and Risks networks respectively;

w_B, w_O, w_C, w_R – weights of networks Benefits, Opportunities, Costs and Risks respectively.

The results of synthesis are shown in Figure 10.



Alternatives	Benefits-Opportunities	Risks	Multiplicative	Additive
Weight of networks	0,7262	0,2738		
A	0,2188	0,0776	0,2504	0,2603
B	0,2707	0,0336	0,3675	0,3543
C	0,2142	0,7077	0,1346	-0,0723
D	0,2964	0,1812	0,2475	0,3132

Figure 10. Results of synthesis

2.5 Sensitivity analysis

Sensitivity of the results to any changes of the initial priorities is realized through the line graph. Firstly, we choose where priorities will be changing (in what hierarchy, network or control hierarchy) and then choose appropriate clusters or nodes. The selected priority will be changed from 0 to 1, and global priorities of the alternatives will be calculated. For the obtained points the line graph will be drawn. Vertical lines on the graph mark an interval (5% on default) which illustrates actual increments of the initial priority.

An example of sensitivity analysis is shown in Figure 11.

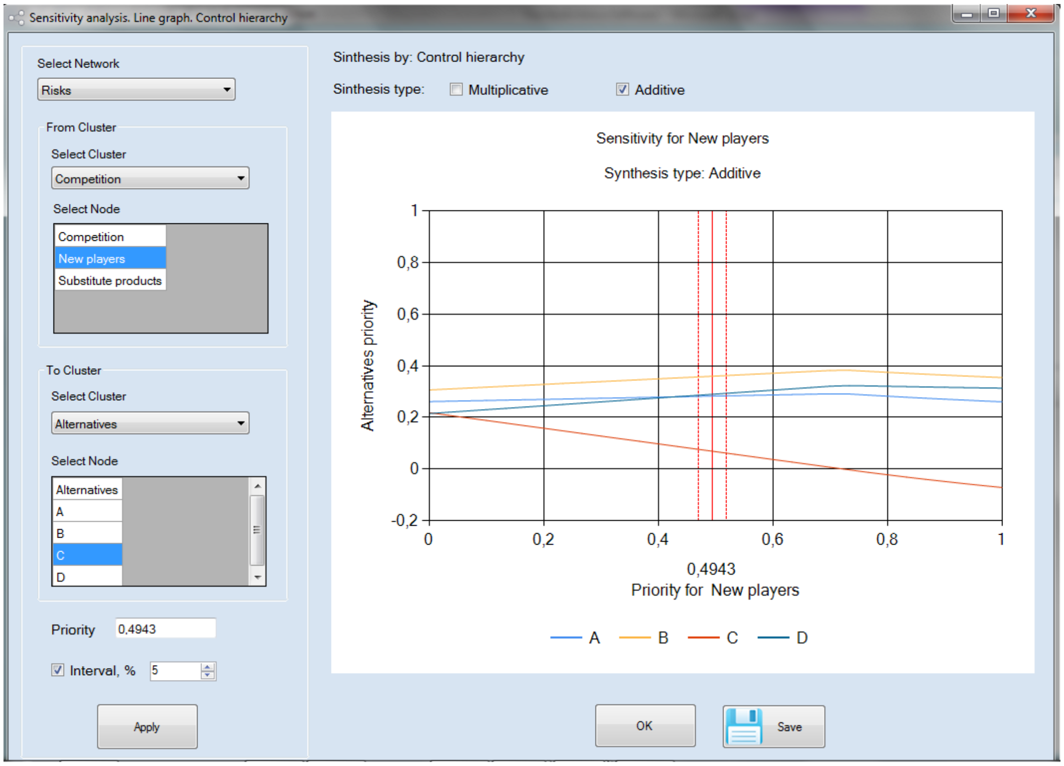


Figure 11. Sensitivity analysis

3. Discussion

ANP and AHP are widely used for decision analysis in economic, political, social and technological applications (Saaty &Vargas, 2006). Forman and Gass (2001) believe that the real essence of AHP is not generally understood and AHP is more than just a methodology for choice.

Thus, the best way we can develop the ANP/AHP technology is to implement all capabilities of the theory using modern software. The software must not only satisfy all of the user's needs, but also it should be constantly evolving. Thus, further implementation of ANP/AHP algorithms in Multichoice is essential: other types of elements evaluation, incomplete pairwise comparisons, various visualization capabilities (e.g. graphs for visualizing the results of linguistic estimation).

A new round of development of ANP/AHP technology can be implemented by creating a global decision-making web portal. A portal will accumulate and aggregate theory and best practice of ANP/AHP and, mostly importantly, have a web interface for analyzing decision problems online.

4. Conclusions

Multichoice software has been created to support decision making with ANP/AHP. The first version of the software has a user-friendly interface and contains all instruments to implement base functions of ANP/AHP: model constructing, elements evaluation, different ways of to obtain, synthesize, visualize and export results, sensitivity analysis.

Future versions of the software may contain advanced functions related to modern decision making, such as different types of estimation (e.g. incomplete pairwise comparisons), different graphs for best data visualization, and anything that is needed by ANP/AHP researchers.

We also propose the idea of creating a web portal as a global resource for aggregating theory and practice of ANP/AHP and making decisions online. The authors are open to all proposals and ideas for further development of the ANP/AHP technology.

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