

Multi-Criteria Decision Support Systems. Comparative Analysis

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Abstract: In a highly competitive business environment the right decision may bring success to a company while the wrong one may lead to collapse. Making the right choice is a difficult task, especially if there are multiple criteria. Therefore companies to remain competitive in a highly-demanding market have to know how to make decisions right. This article aims to compare existing computerized multi-criteria decision support systems and provide recommendations on implementing them in Kazakhstan. Analysis includes review of multi-objective decision making methods and tools available to facilitate the work of decision makers, selection a group of DSS software to study, comparing the key characteristics of selected multi-criteria DSSs, identifying the best alternative(s) and providing final recommendations for accepting such tools by decision makers in Kazakhstan. Authors of the article have selected and analyzed 10 decision-making software packages and developed their suggestions on adopting them in Kazakhstan. Results and conclusion were summarized in the article.

Key words: Decision Support System • DSS • Multi-Criteria Decision Making • MCDM • Decision-Making Software • DMS

INTRODUCTION

Decision makers have to work in very complex conditions - fast-changing, overloaded with information and extremely competitive.

In the aftermath of the recent global crisis, the modern firm should proactively respond to the disruptive changes in the dynamics of markets, new technologies and the new architecture of the competition. But in real word it is very difficult to change, to adapt and to innovate in the context of a centralized managed process. It is necessary a new paradigm of intelligent decision making, more generalized, more flexible and more adaptable to change [1].

Development of communication networks that provide fast speed and access to different information and significant progress reached in developing artificial intelligence techniques has resulted in very complex tools aimed to support decision making process under such risky and uncertain conditions. These tools have

significant potential to improve decision making by suggesting solutions better than those made by humans alone. Such systems are now more and more available in different fields from general business usage to engineering applications and traffic control.

One of ways to accomplish the goal of bringing together the appropriate information and models for informed decision making is to use decision support systems (DSS). Decision support systems are computer-based systems that bring together information from a variety of sources, assist in the organization and analysis of information and facilitate the evaluation of assumptions underlying the use of specific models. In other words, these systems allow decision makers to access relevant data across the organization as they need it to make choices among alternatives. The DSS allow decision makers to analyze data generated from transaction processing systems and other internal information sources easily. In addition, DSS allow access to information external from the organization. Finally, DSS

allow the decision makers the ability to analyze the information in a manner that will be helpful to that particular decision and will provide that support interactively [2].

DSS nowadays are extensively used in business and management. Executive dashboards and other business performance software allow faster decision making, identification of trends and better allocation of business resources. A DSS can be designed to help making decisions on the stock market, or deciding which area or segment to market a product toward.

Among Advantages of Computerized DSS Are:

- Decision makers can perform large number of computations in short time.
- Decentralized data of different types with complex relationships may be searched, transmitted and processed quickly.
- Decreased risk of human errors and improved reliability of results.
- Computerized system can improve the quality of decision by obtaining and evaluating more alternatives.

MATERIALS AND METHODS

Research methodology for comparing multi-criteria DSSs that may be utilized in Kazakhstani environment includes review of decision making methods and tools available to facilitate the work of decision makers, selecting a group of software for comparison, comparing advantages and disadvantages of selected multi-criteria DSSs, identifying the best alternative(s) and providing final recommendations for accepting such tools by decision makers in Kazakhstan.

Multi-Objective/Attribute Decision Making and Multi-Criteria Decision Support Systems: Decisions in the real world contexts are often made in the presence of multiple, conflicting and incommensurate criteria. Particularly, many decision problems at tactical and strategic levels, such as strategic planning problems, have to consider explicitly the models that involve multiple conflicting objectives or attributes. Managerial problems are seldom evaluated with a single or simple goal like profit maximization. Today's management systems are much more complex and managers want to attain

simultaneous goals, in which some of them conflict. For a profit-making company, in addition to earning money, it also wants to develop new products, provide job security to its employees and serve the community. Managers want to satisfy the shareholders and, at the same time, enjoy high salaries and expense accounts; employees want to increase their take-home pay and benefits. When a decision is to be made, say, about an investment project, some of these goals complement each other while others conflict.

Multi-criteria decision making (MCDM) refers to making decision in the presence of multiple and conflicting criteria. Problems for MCDM may range from our daily life, such as purchase of a car, to those affecting entire nations, as in the judicious use of money for the preservation of national security.

MCDM Problems Share the Following Common Characteristics:

- Multiple criteria: can be objectives or attributes.
- Conflicting among criteria: multiple criteria conflict with each other.
- Incommensurable unit: criteria may have different units of measurement.
- Design/selection: solutions to an MCDM problem are either to design the best alternative (s) or to select the best one among previously specified finite alternatives.

There are two types of criteria: objectives and attributes. Therefore, the MCDM problems can be broadly classified into two categories:

- Multi-objective decision making (MODM) - concentrates on continuous decision spaces, primarily on mathematical programming with several objective functions.
- Multi-attribute decision making (MADM) - focuses on problems with discrete decision spaces [3].

Some of available MCDM methods, many of which are implemented by specialized decision-making software include:

- Aggregated Indices Randomization Method (AIRM)
- Analytic hierarchy process (AHP)
- Analytic network process (ANP)

Table 1: DSS Description

Program/ Developer/ Price	Main Capabilities
1000Minds (1000Minds Ltd.) Free for academic purposes, other negotiable	Helps with decision-making, prioritization and discovering stakeholder preferences. Depending on application, can also help in considering alternatives and allocation of budget or other scarce resources. As well as stand-alone decision tools, offers customizable processes to include potentially up to 1000s of participants in a variety of group decision-making activities. Applies patented PAPRIKA (Potentially All Pairwise Rankings of All Possible Alternatives) method. Web-based software with a tab-based interface. Preferences with numerous pairwise questions on criteria. Various ways to analyze results. Sharing results on the net and possibility for voting or surveys.
Analytica (Lumina Decision Systems, Inc.) Professional version \$995	Helps in building business models or policy analysis. Has intuitive influence diagrams for creating models and allows communicating clearly with colleagues and clients. Its Intelligent Arrays allows creating and managing multidimensional tables with an ease and reliability and efficient Monte Carlo allows quickly evaluating risk and uncertainty and finding out what variables really matter and why. Object-oriented visual interface, with which one can implement practically any method. Various graph-building. Pre-defined modules available, for example, for MAUT, optimization, and risk analysis. Various distributions available.
Criterion Decision Plus 3.0 (InfoHarvest) \$895.00	Can be used for managing the entire decision process. Applying a structured methodology to decision making helps in making precise, thoughtful and completely supportable decisions. Includes Direct Tradeoffs, larger models, powerful graphics and extensive options for supporting insightful, persuasive decision making faster and for more complex models than ever. Basic MAVT software with AHP functionality.
Decide IT (Preference) Free for academic use. Commercial license _1900 + _900/year.	Enables to carry out reliable risk and decision analyses. Includes state-of-the-art decision methodologies and mathematical analysis in an efficient and user friendly software. Comes with an easy-to-use graphical user interface in which decision trees together with criteria hierarchies 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 and show the internal relations between options, objectives and uncertain parameters. MCDA software providing both value and decision tree approaches. Uses intervals and inequality relations in weighting. Probabilistic analysis of imprecise results.
Decision Tools (Palisade Corporation) Depends on the license (Stand-alone single-user license: £2000)	Integrated set of programs for risk analysis and decision making under uncertainty that runs in Microsoft Excel. Includes @RISK for Monte Carlo simulation, PrecisionTree for Decision Trees, and TopRank for "What-If" sensitivity analysis. In addition, comes with StatTools for statistical analysis and forecasting, NeuralTools for predictive neural networks and Evolver and RISKOptimizer for optimization. All programs integrate completely with Microsoft Excel for ease of use and maximum flexibility.
GMAA (Universidad Politécnica de Madrid) Available free of charge for academic purposes	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. MAUT software with a possibility to use intervals to model imprecision.
Logical Decisions (Logical Decisions) 1 installation: \$895.00	Allows evaluating choices by considering many variables at once, separating facts from value judgments and explaining choices to others. Uses techniques from the field of decision analysis to help in making more effective decisions. Provides a variety of methods for assessing attribute weights and has many results displays. Basic MAVT software with AHP functionality.
M-MACBETH (Bana Consulting Lda) Free demo available, academic license _175, professional _1750	Uses interactive approach that requires only qualitative judgments about differences to help a decision maker or a decision-advising group quantify the relative attractiveness of options. Employs an initial, interactive, questioning procedure for comparing two elements at a time, requesting only a qualitative preference judgment. As judgments are entered into program, it automatically verifies their consistency. A numerical scale is generated that is entirely consistent with all the decision maker's judgments. Through a similar process weights are generated for criteria. MAVT software that support Macbeth method, various graphical ways to assess the parameters.

Table 1: Continue

Program/ Developer/ Price	Main Capabilities
TESLA (Quintessa)	Software tool for supporting decision makers when faced with complex decision problems. 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 categorized. Software with decision tree approach and evidence based updating of probabilities.
V.I.S.A. Decisions (SIMUL8 Corporation Ltd)	Standard version (Includes standalone application and web-based version) \$495 Created for decisions with multiple, tough to balance factors; 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 allows weighing up all the factors using a considered and sound process and documents how decision was made and why it was the right outcome for future reference. Basic MAVT software [8].

- Data envelopment analysis (DEA)
- Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH)
- Multi-attribute utility theory (MAUT)
- Multi-attribute value theory (MAVT)
- Nonstructural Fuzzy Decision Support System (NSFDSS)
- Potentially all pairwise rankings of all possible alternatives (PAPRIKA)
- PROMETHEE (Outranking)
- Simple multi-attribute rating technique (SMART)
- (Fuzzy) VIKOR methods and other [4].

Decision-making software (DMS) is a type of DSS to help individuals and organizations with their decision-making processes, typically resulting in ranking, sorting or choosing from among alternatives. Most of DMS currently focuses on choosing from among a group of alternatives characterized by multiple criteria or attributes and employ multi-criteria decision making (MCDM) [5].

In this work we've considered 10 DSS available now.

RESULTS AND DISCUSSION

One of the ways for evaluating decision making tools is proposed here [6]. It assumes numerical ranking of software attributes (such as interface, math and graph tools, time estimation, export, reporting and other features) on (0-10) scale with calculation of final scores for each selected product. Modification of this method was implemented by authors of this article for evaluating a group of 10 selected multi-criteria DSSs (MCDSSs).

While making analysis, it is important to remember, as stated by [7], that simple inclusion of intelligent features in MCDA DSS may undermine the primary mission of a DSS as a decision aiding, not making tool. Taking into account the potential user and problem area, the acceptance of intelligent techniques should be always

judged from the point of view of the advantages and disadvantages they bring in a particular decision process.

Results of comparative analysis of 10 selected MCDSSs are presented in Table 2

In Table 3 (Grey color highlights the best system in its category. Second row shows final rating of systems - with "1" being the best).

Conducted analysis show that features and capabilities of selected software under study are very similar to each other. This can be explained by standardized multiple-criteria data analysis process implemented in such software. Nevertheless, there are differences in particular methods used and in results presentation mechanisms.

Most of selected software is proprietary with prices ranging from approx. \$250 to \$2500, showing 10x price gap. Palisade Decision Tools software seems to be the only one providing full-featured localization support in several languages (with no support for Kazakh or Russian), while other are mostly in English, but from the other side being the one of the most expensive.

Almost all systems are running on Windows platform with one (1000Minds) designed to be used with Web interface.

Common trend in the analyzed programs seems on being multi-purpose software providing several different methods for various cases. From the one side, it allows utilizing software in big variety of different situations, but from the other side, this flexibility also requires certain expertise from a decision maker to use such software (expertise level 3 is required by most of applications).

The best choice from selected alternatives seems to be V.I.S.A. Decisions solution with slightly bigger set of features and moderate price; therefore it has higher chances for adoption in local environment.

Main disadvantage of analyzed DSS software is that they are commercial and quite expensive, which prevents them from being widely used by SMEs or by individual entrepreneurs in Kazakhstan.

Table 2: Comparative analysis of multi-criteria decision support systems.

	1000Minds	Analytica	Criterion Decision Plus 3.0	DecideIT	Decision Tools
Final Rating	5	3	2	9	10
Initial release	2002	January 16, 1992	N/A	2002	1987
Type, License, Fee	Proprietary Free for academic purposes, other negotiable	Proprietary Professional version	Proprietary \$895.00	Proprietary Free for academic use. Commercial license _1900 + _900/year.	Proprietary Depends on the license (Stand-alone single-user license: £2000)
Language of user interface	English	English	English	English	English, Spanish, German, French, Portuguese, Japanese
Platform	Web browser	Windows x86	Windows x86	Windows	Windows
Supported MCDA methods	PAPRIKA, MAUT/MAVT	MAUT/MAVT	MAVT, AHP, SMART	MAUT	N/A
General-purpose software	Yes	Yes	Yes	Yes	Yes
Process support	Yes	No	No	No	No
Hand-in-hand guidance	Yes	No	No	No	No
Level of expertise required	2	3	3	3	3
Hierarchical model	No	Yes	Yes	Yes	Yes
Consequences table	Yes	Yes	Yes	No	Yes
Visual scoring	No	Yes	Yes	Yes	No
Visual weighting	No	Yes	Yes	Yes	No
AHP/Pairwise comparison	Yes	No	Yes	Yes	No
MAUT/MAVT	Yes	Yes	Yes	Yes	No
Swing	No	Yes	Yes	No	No
Outranking	No	No	No	No	No
Modeling by uncertainties	No	Yes	No	Yes	Yes
Decision Trees	No	No	No	Yes	Yes
Visual Graphs	Yes	Yes	Yes	Yes	Yes
Overall values	Yes	Yes	Yes	Yes	No
Sensitivity analysis	Yes	Yes	Yes	Yes	Yes
X-Y graphs	Yes	Yes	Yes	Yes	Yes
Written Report	Yes	No	No	No	Yes
Group model	Yes	No	No	No	No
Excel model	No	Yes	Yes	No	Yes
Score:	12	13	13	11	10

Table 3: Comparative analysis of multi-criteria decision support systems (continued).

	GMAA	Logical Decisions	M-MACBETH	TESLA	V.I.S.A. Decisions
Final Rating	8	4	6	7	1
Initial release	2003	N/A	2005	2007	2013
Type, License, Fee	Available free of charge for academic purposes	1 installation: \$895.00	Free demo available, academic license _175, professional _1750	N/A	Standard version (Includes standalone application and web-based version) \$495
Language of user interface	English	English	English, French, Portuguese, Spanish	English	English
Platform	Windows	Windows	Windows	Windows	Windows
Supported MCDA methods	MAUT	AHP, MAUT	MAVT, MACBETH	N/A	MAVT
General-purpose software	Yes	Yes	Yes	Yes	Yes
Process support	No	No	No	No	Yes
Hand-in-hand guidance	No	No	No	No	Yes
Level of expertise required	3	3	3	3	3
Hierarchical model	Yes	Yes	Yes	Yes	Yes
Consequences table	Yes	Yes	Yes	No	Yes
Visual scoring	Yes	Yes	Yes	Yes	Yes
Visual weighting	Yes	Yes	Yes	Yes	Yes
AHP/Pairwise comparison	No	Yes	Yes	No	No
MAUT/MAVT	Yes	Yes	Yes	No	Yes
Swing	No	Yes	No	No	Yes
Outranking	No	No	Yes	No	No
Modeling by uncertainties	Yes	No	No	Yes	No
Decision Trees	No	No	No	Yes	No
Visual Graphs	Yes	Yes	Yes	Yes	Yes
Overall values	Yes	Yes	Yes	Yes	Yes
Sensitivity analysis	Yes	Yes	Yes	Yes	Yes
X-Y graphs	Yes	Yes	Yes	Yes	Yes
Written Report	No	Yes	No	Yes	Yes
Group model	No	No	No	No	No
Excel model	No	No	No	Yes	No
Score:	11	13	12	12	14

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