Objectives´ Evaluation as Knowledge Development

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ABSTRACT

Many managerial problems involve multiple criteria decision-making. For such decision making the user needs to set his/her objectives, define decision criteria and decision alternatives. The criteria weights represent individual preferences, but some general rules and methods can be applied. Simple methods for criteria weights assessment are based on comparison of their importance. The multiple criteria decision-making is often supported by results of so called consumers´ tests. These tests are not directly applicable for decision-making, but there are ways for exploitation of the information included. Ability to exercise the multiple criteria decision-making model including criteria weights construction represents new quality: knowledge. This knowledge contributes to organizational and individual learning and becomes a part of the organization memory.

Keywords: decision support, multiple criteria decision making, criteria weights, knowledge based organizational learning

1. INTRODUCTION

For years, solving managerial problems was based on creativity, judgment, intuition and experience. However, the environment in which management operates today is changing very rapidly and the trend is towards increasing complexity. The impact of computer technology on organizations and society is increasing and interaction and cooperation between people and machines are rising. Computer applications are moving from transaction processing to problem solution applications. In these applications the management science approach as systematic process is often adopted. This approach is connected with mathematical modeling, which transforms the real-world phenomenon into a prototype structure. The mathematical models are practically useful as part of expert systems or decision support systems.

Decisions can be made by individuals and there might be conflicting objectives even for a sole decision maker. Most major decisions are made by groups. The groups include people of different specialization, education, experience, etc., so that the conflicting objectives occur with the highest probability. There are many tools how to handle with conflicting criteria. The user always has to find information about existing decision alternatives. Then it is in almost all cases necessary to evaluate the criteria - to set the criteria weights. The criteria weights assessment can be understood as a separate decision making problem. The weights assessment represents individualization of given decision-making method because the relative importance of a criterion is different for each user. This is the reason why the criteria weights are not part of mathematical methods and software packages. Definition, analysis and solution of this problem lead to a new quality. The user is able to use chosen mathematical method only when he/she is able to construct individual criteria weights.

2. MULTIPLE CRITERIA DECISION MAKING

According [1] the decision making process involves three major phases: intelligence, design and choice. In intelligence phase the problem is examined and defined, in the design phase the model is constructed and the choice phase includes selection of one proposed solution. The decision maker sets up the goal or desired level of performance. Usually there is not only single goal or single characteristic, which should be achieved. Several goals are often in contradiction as for example, profit maximization and cost minimization, the highest quality and lowest price, etc. Therefore, it is often necessary to analyze each alternative in light of each of several goals.

The problems of MCDM are widely diverse. However, even with the diversity, all problems that are considered share the following common characteristics according to [2]:

1. Multiple objectives/attributes: A decision maker generates several relevant objectives for each problem.

2. Conflict among criteria: Multiple criteria usually conflict with each other.
3. Incommensurable units: Each objective has a different unit of measurement. Some objectives are even measures non-numerically as design, quality, etc.
4. Design/selection: Solution of these problems is either to design the best alternative or to select the best alternative among previously specified finite alternatives.

According to point 4. the MCDM problems can be classified into two categories:

A. The alternatives are not predetermined and the goal is to design the "best" (compromise) alternative by considering set of constrains leading to an acceptable level of a set of quantitative objectives.
B. A limited (and accountably small) number of alternatives are defined. The alternatives have associated with them a level of the achievement of the attributes based on which the final decision is to be made. The final selection of the alternative is made with help of inter and intra attribute comparisons.

Even if both categories are two facets of the same decision making problem we concentrated on decision making in predetermined set of alternatives, which is called Multiple Attribute Decision Making (MADM).

A MADM problem is often expressed in decision matrix format. The decision matrix is a (m x n) matrix, where *m* is a number of decision alternatives and *n* is a number of criteria. It means, the decision alternatives are in lines and the attributes are in columns. The line in the decision matrix represents evaluation of one alternative under all criteria and the column contains evaluation of all alternatives under one criterion. Each element of the decision matrix x_{ij} indicates evaluation of i-th alternative under j-th criterion. For many methods, the decision matrix contains also criteria weights in a special line on the top of the matrix.

2.1. MADM Model Inputs

For MADM models the user has to collect following inputs:

1. Objectives: An objective generally indicates the direction of change desired, i.e. profit maximization, product cost minimization, etc.
2. Goals: Goals are a priori values or levels of aspiration, which are to be either achieved or surpassed or not exceeded. In fact they reduce the set of alternatives and function as constrains.
3. Criteria: A criterion is a measure of effectiveness and a basis for evaluation.
4. Criteria weights: A criterion weight reflects the relative importance of the criterion in comparison with other criteria in the model.
5. Attributes: Attributes are properties of alternatives. Each alternative is characterized by attributes under all criteria.

Top management of the firm as a result of another decision-making process usually sets the general objectives. The goals represent partial objectives and contain concrete quantitative indicators. The objectives and goals must be set before the construction of MADM model starts. The model construction itself contains following steps:

1. Criteria definition – The user defines criteria of decision making. We recommend use of a model of similar decision situation and add or remove some criteria according to previously set objectives and goals.
2. Decision alternatives definition – The number of decision alternatives must be satisfying for concrete decision problem. On one hand it has to cover properly the decision space, on the other hand the cost for attribute collection and processing must be reasonable and in line with the importance of the problem solved.
3. Alternative attributes collection – The user has to collect attributes (data and information) for each alternative under each criterion. In this phase often appears that attributes for some criteria are not available in normally used sources. In such a case we recommend to revise the list of criteria, remove the problematic criterion or change its definition. Other way is to investigate the alternatives in details by own or try to reach other sources of information. In all cases we have to bear in mind the costs and purpose of the model.
4. Criteria weights construction – The criteria weights represents relative importance for decision maker. There are many objective quantitative methods, which can be used but some kind of information on users´ preferences is always necessary.

5. Decision matrix construction – collected data and information are formally organized in a decision matrix.

Information for MADM model construction (including data and knowledge) is often stored in a text and/or numerical format and must be accessed by decision maker; that's why the database organization plays a major role in the MADM model construction. The text inputs can sometimes be transferred into numbers via special methods or using fuzzy logic.

After the MADM model construction the user should choose proper MADM method and realize the final choice of the alternative.
The final choice is a routine procedure usually realized by software tool but the previous objective and goal definition, model construction and method choice involves in fact several partial decisions, each of which may need special expertise and could represent also a MADM problem.
Because described system of decisions is complicated we concentrated only on the criteria weights assessment, which represent non-routine part of decision making with strong influence to the final solution. A comparable problem exists in different organizations and certain non-routine problems can repeat themselves in the same functional area (finance, supply management). Therefore, it makes sense to develop some methodological general starting points for criteria weights assessment and their management.

3. CRITERIA WEIGHTS AS KNOWLEDGE

The criteria weight by our point of view represents new knowledge, which becomes an object of knowledge management.

Knowledge has strong experimental and reflective elements that distinguish it from information in a given context. Having knowledge implies that it can be exercised to solve the problem For example; two people in the same context with the same information may not have the same ability to use the information due to different experience, training, or other differences. The knowledge provides a higher level of meaning about data and information. It conveys meaning. By [3] the knowledge can be characterized by:

- Ground truth – the truth gained from experience not from theory
- Complexity – complex approach to problem solving
- Judgment – involves context and evaluation
- Heuristics – guides and simplifications for problem judgment
- Values and benefits – different people have different problem solving frames

Potential sources of knowledge include human experts, textbooks, multimedia documents, private and public databases, special research reports, and information available on the web, where acquiring knowledge from experts is a complex task that often creates a bottleneck.

4. CRITERA WEIGTS CONSTRUCTION

4.1. Life Cycle

The construction of criteria weights can follow the traditional system development life cycle: planning, analysis, design, and implementation. The construction involves also testing and verifying. All user's expectations must be managed throughout the development process and the developers have to understand the decision-making problem. Learning is explicitly integrated into the design process. Understanding the criteria weights construction as a life cycle implies that all cycle or some phases should be repeated until the objectives are reached. It is also necessary to repeat the construction process after some changes in objectives, in organizational culture and in individual experience and motivation.

4.2. Organizational Learning and Memory

Organizational learning is the development of new knowledge and insights that have the potential to influence behavior. The learning cultivates the organizational memory, which represent the informational source of the organization. The ability of an organization to learn and share knowledge is a part of the organizational culture. The criteria weights are a part of the organizational memory and the way in which they can be changed depends highly on the organizational culture. Some firms insist on the same objectives, on the same emphasis on partial goals, for a long time, which may cause their ill adaptation to changing business condition. Therefore, consecutive evaluation of objective through collaborative and communication technologies is implied in the organizational culture of successful enterprises.

4.3. Some Methods for Criteria Weights Construction

Very often we have to choose the best alternative generally without information about future users or applications. For such a task we must apply some method without preference information, i.e. without criteria weights. These methods are for example: maximin, maximax and graphical method. Also the methods based on given acceptable (standard) levels do not necessarily call for criteria weights assessment - conjunctive and disjunctive method.

Quite often the user is able to express the ordinal inter-criterion preference, i.e. compare criteria and evaluate which is more important.

One approach is based on ordering all criteria in the model. The *order method* is based on ordering criteria from the most important to the least important. The most important criterion is evaluated by number k (k is number of criteria in the model), following less important by $k-1$, etc. The least important criterion is evaluated by 1. The criteria weights we get as

$$v_i = \frac{p_i}{\sum_{i=1}^{k} p_i},$$

where p_i the numbers assigned to each criterion.

Second group of methods is based on pair wise comparison. The *Fuller triangle* method is based on a triangle scheme, which contains pair of criteria. Each pair is only once in the scheme and each criterion is in pair with all other criteria. In each pair the user chose one criterion and mark it. The number p_i is than equal to number of marks given to i-th criterion. *Saaty´s method* uses the principle eigenvector of a positive pair wisecomparison matrix. The Saaty´s matrix has all positive elements and the reciprocal property see [2].

If the user is able to express directly the quantitative evaluation of criteria importance (the cardinal information on preference), the *score method* is applicable. It is necessary to create a scoring scale first. The p_i numbers assigned to each criterion are chosen from the scale.

5. CASE STUDY

To illustrate our premises we chose evaluation of various post agents. We organized the data from [4] into decision matrix. The post agents represent decision alternatives see *table 1*.

No. of decision alternative	Name of postal client
1	Outlook Express
2	Mozilla
3	Pegasus Mail
4	Outlook 2003
5	Lotus Notes

table 1 List of decision alternatives

To judge the quality of all clients we adopted the gauge from [5], which could be used as decision criteria – see table 2.

No. of decision criterion	Name of function
1	Complete heading
2	Distribution lists
3	Image filter
4	Calendar
5	Spelling check
6	Cognizance copy
7	Unsolicited message
8	Meeting planner
9	Delivery confirmation
10	Reading confirmation
11	Message priority
12	Attachments
13	Message appearance
14	Folders
15	Multiple users
16	Searching
17	Security
18	Back-up

table 2 List of decision criteria

The decision matrix in table 3 contains the decision alternatives in lines and the decision criteria in columns. The evaluation of all alternatives under each criterion could be:

0… the function is not implemented

1…the function is implemented in average extend

2…the function is implemented in higher than average extend

The definition of criteria will be naturally different for different classes of software tools. Also the evaluation scale need not be the same for other cases, it could be even different for each function (criterion).

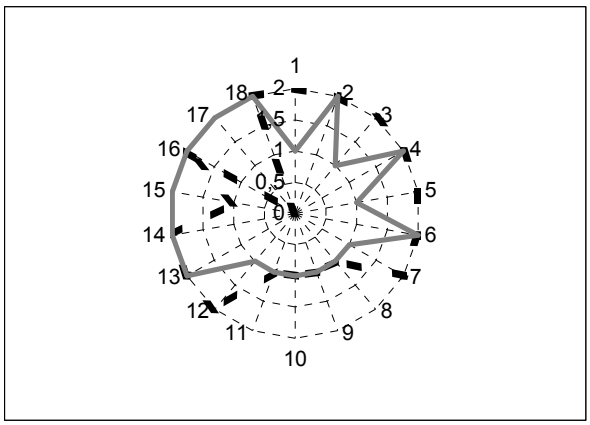
No. of criterion																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	2	2	0	1	2	0	0	0	1	1	1	1	2	1	2	0	1
2	2	2	1	1	2	1	0	0	1	1	1	2	2	2	2	1	0
2	2	0	0	1	2	2	0	1	1	1	1	2	1	2	2	1	0
2	2	2	2	2	2	2	1	1	1	1	2	2	2	1	2	0	2
1	2	1	2	1	2	1	1	1	1	1	1	2	2	2	2	2	2

table 3 Decision matrix

5.1. Selection with No Information on User's Preference

For our case we used graphical method, which is able to find dominated and non- dominated alternatives.

From the graphical solution we found that the alternatives 1,2,3 are dominated by alternative 4. The alternatives 4 and 5 are non-dominated.



Picture 1 Graphical presentation of non-dominated alternatives 4 and 5

The dominated alternatives are worst or equal to some other alternative in all criteria and can be dropped out. In the set of non-dominated alternative we calculate the area of both polygons and compare them. The bigger area indicates the better alterantive. For the polygon area calculation we used following formula:

$$P_i = \sin\frac{2\pi}{k}\sum_{j=1}^{k} f_{i,j}\cdot f_{i,j+1}\text{ , where}$$

k….number of criteria

f_{ij} …evaluation of i-th alternative under j-th criterion

We got 14.7 for alternative 4 and 13.3 for alternative 5. The recommended alternative is then alternative 4.

5.2. Selection with criteria weights

In the cases, when the user is able to express his/her criteria preference we can use a wide range of methods. We chose simple additive weighting method (SAW) and tried to evaluate the alternatives using different criteria weights.

For the first trial we assign all criteria the same weight 1/18.

For the second trial we assigned to criteria 15 and 17 in which the alternative 5 is better higher weights 0.2 and 0.038 for all other criteria.

For the third trial we assigned lower weights to criteria 15 and 17: 0.02 and 0.06 to all others.

The results are in *table 4*.

Trial	Criteria weights		
	1	2	3
1	0,056	0,05	0,06
2	0,0556	0,05	0,06
3	0,0556	0,05	0,06
4	0,0556	0,05	0,06
5	0,0556	0,05	0,06
6	0,0556	0,05	0,06
7	0,0556	0,05	0,06
8	0,0556	0,05	0,06
9	0,0556	0,05	0,06
10	0,0556	0,05	0,06
11	0,0556	0,05	0,06
12	0,0556	0,05	0,06
13	0,0556	0,05	0,06
14	0,0556	0,05	0,06
15	0,0556	0,1	0,02
16	0,0556	0,05	0,06

17	0,0556	0,1	0,02
18	0,0556	0,05	0,06
Best alternative	4	5	4

table 4 SAW results with different weights

6. DISCUSSION

Many solved multiple criteria decision-making problems appear in the form of consumers' tests, on the web or in other records. We don't think that the results can be directly used for decisions. The recommended alternative is not necessarily the best for particular user. But we suppose the attributes of alternatives in these tests are correct and can be adopted.

The user should analyze the assortment of criteria. If he/she agrees with chosen criteria, the whole decision matrix can be adopted. Similar procedure can be applied if the user decides to reduce the number of criteria, i.e. to discharge some of them.

What cannot be adopted are the criteria weights. Even if the criteria weighs can be different for each situation and each individual decision makers we recommend following rules for their construction:

- Find similar problems – inside the own organization first, than outside.
- Try to understand which criteria weights were used and why.
- Compare the actual situation with references.
- List the criteria according to their importance (ordinal information on preferences).
- If possible specify the different importance more precisely (cardinal information on preferences).
- Use some quantitative method for weights assessment (methods based on ordinal or cardinal information, special methods for non numerical information)
- Compare the constructed criteria weights with references.
- Find differences and try to find reasons of these differences (different objectives, constrains, external influences)
- If the differences are reasonable keep it, if not go back to formulation of ordinal or cardinal information on preferences.

The users´ tests can be applied only when recharged with disposable instructions how to create own criteria weights. It is convenient to complement the attributes of alternatives with software tool for criteria weights assessment.

In many cases the criteria weights are not published. In such cases the user should be very careful because the weights can be of crucial importance. The solution can be even distorted on purpose.

Generally the consumers test represents information. To transfer this information into knowledge the user needs to know how to construct and use the multiple decision making model. The soft ware tools for decision support are usually behind this aim.

7. CONCLUSIONS

The criteria weights represent individual preference of the user. The knowledge of the weights represents not only the real numbers as adequate information but includes the way to construct them. The user who is not able to understand how and why the weights were constructed is not able to use them properly. For concrete decision-making problem he/she cannot just adopt the weights from another problem or from another expert. For the weights construction the user has to learn proper methods and be able to use them in real cases. Some of these methods are quite complicated; sometimes it could be difficult to express the individual preferences. The knowledge which is a part of the organizational memory includes not only various methods for criteria weights construction but also simple and direct support of decision maker.

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