# Decision Support System with Mark-Giving Method

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Abstract: Just as in many other areas, strategic management makes use of mathematical modelling in cases such as setting strategic goals, formulation of strategies, selection and realization of the chosen strategy, and strategic control. Criteria and restrictions of alternatives are also encompassed in the space of uncertainty and indeterminacy. They have multiple meanings, in addition to being incomplete and fuzzy. The ordering method is based on the assessment, i.e. mark-giving method used by teachers in education. Values of criteria are treated as fuzzy sets, given as marks. It can be easy programmed by fuzzy logic software.

## 1 INTRODUCTION

The sense, value, manner and process of decision-making problems are determined by the cultural, social, temporal, value, as well as logical context. Fuzzy logic was developed more than five decades ago. The characteristics of fuzzy logic include operating by fuzzy notions, imprecise authentication tables, and fuzzy inference rules. All these characteristics of fuzzy logic are highly important, especially if we try to exchange or supplement the long-dominating approach of strategic decision making with the descriptive one.

The fuzzy set theory and various mathematical reviews, the measures of uncertainty and information have an unlimited possibility of application in all the fields of sciences using a lot of information and data, like for instance, in decision-making. The contexts of strategic management are under the conditions of uncertainty and indefiniteness (Dubois and Prade, 1980).

The criteria, limitations and performances of measures of alternatives bear in themselves some aspects of indefiniteness: in determinativeness, multiple aspects of meaning, incompleteness and fuzziness.

## 2 FUZZY DECISIONS

As the name says, the subject of the decision making discipline is the study of how decisions are really made, and how they can be made better and more successful.

The predominant focus of this discipline was in the area of business decision making, where the decision-making process is of key importance for functions such as investment, new product development, resource allocation, and many others.

Fuzzy systems approximate those equations. Fuzzy systems enable us to make optimum approximations of the non-linear universe. If it is possible to build a mathematical model, we shall use it. Fuzzy systems enable us to model the universe in linguistic terms, rather than forcing us to write a mathematical model of the universe. The technical term for it is *model-free function approximation*.

The Fuzzy Approximation Theorem claims that a graph can always be covered with a finite number of fuzzy patches. The more uncertain the rule, the larger the fuzzy patch. According to the Fuzzy Approximation Theorem, a fuzzy system can approximate a continuous system to a sufficient degree of accuracy. This includes almost all systems studied by science. Fuzzy systems can model dynamic systems changing over time.

Viewed geometrically, every portion of human knowledge, each rule “if A then B” defines a patch on a graph. A fuzzy system is a large set of fuzzy “if then” rules, representing “a large set of patches”. The more knowledge, the more rules. The more rules, the more sets. If the rules are more indefinite, i.e. uncertain, the patches are larger. If the rules are more definite, the patches are smaller. If the rules are so precise that they are not fuzzy, then patches are reduced to points.

The Fuzzy Approximation Theorem says more


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than that. Theoretically, all equations can be translated into rule patches. Fuzzy systems approximate systems in physics, communication, physiology, etc. Fuzzy systems can be applied wherever the brain is used.

It is hard to deny that modern-day knowledge is fuzzy. Meanings of statements are undoubtedly fuzzy. Knowledge has always been regarded in terms of rules. If knowledge is fuzzy, then rules are fuzzy as well. Fuzzy rules connect fuzzy sets. Fuzzy knowledge comprises fuzzy rules, and “if A then B” rule. Fuzzy patches cover the system graph. It is the Fuzzy Approximation Theorem and fuzzy patches that explain the functioning of fuzzy systems.

## 2.1 Fuzzy Linear Programming

Operational research offers optimization models aimed at finding an activity programme that will yield the best possible results. The models use precisely determined and known data. Constraints are also precisely determined, and the goal function is clearly defined, so that it can be formulated easily and simply.

Reality, however, is different: very often we lack precise information on the value of individual input parameters, or the values of coefficients in constraint and goal functions, and imprecise formulation of limitations themselves is possible as well (Maier, 2008).

Fuzzy sets can be introduced into the existing decision making models in several ways. As an economic institution, a company bases its existence on the environment, both from the aspect of providing input and from the aspect of achieving and valorising input. Miscellaneous knowledge and experience, and also decision making in the areas of investment, market operations, financial function, production function or research and development, can be considered more fully and exactly applying fuzzy sets. Under the existing circumstances containing fuzzy characteristics, there is a wish to achieve radical improvements of the production management and decision making.

The need arises for choosing an appropriate corporate goal out of the available possible alternative goals. When accomplishing and executing the alternatives, the company achieves different levels of increase in sales (because, although the subject issue is decision making on production, one must bear in mind that the ultimate goal of production is sale of the produced commodities).

In addition to many constraints under the given conditions, one must particularly bear in mind limitations, i.e. constraints such as:

- that the selected alternative (goal) is to be accomplished in the shortest possible period;
- that investment in accomplishing the selected alternative should not be excessive.

The goal of decision making is a large number of sold products. The decision must best meet the goal and constraints of the given problem.

The nature of the problem displays the characteristics of uncertainty and vagueness. The need for fuzzification, i.e. fuzzy decision making systems from the fact that the decision maker is faced with a large number of scenarios and sub-scenarios out of which the optimum must be chosen, and the imprecision of input data results from subjective approach in interpreting *per se* vague information.

## 2.2 The Mark Giving Method

The basic prerequisite to apply fuzzification for obtaining more effective instruments for using different kinds of uncertainty, as well as for using the natural language in modelling decision-making, in the field of business decision-making of hierarchical level, faces a whole range of problems which cannot be solved by the methods of classical quantitative analysis.

Above all, we would point to the following problems:

- ambivalence of aims,
- variability of factors,
- subjectivity of sight,
- linguistic description of variables.

In practice, we often meet models where multiple criteria take part in decision-making simultaneously. This article is an attempt to prepare a decision by the use of the fuzzy method of ordering alternatives (i.e. aims), and to set priorities among some alternatives and criteria, in the decision-making situations where there are multiple decision-makers, multiple criteria, and in the multiple time periods. The applied method of evaluating in this article is based on the usual assessment, i.e. marking method used in education.

The mark-giving method, very similar to R. Jain's ordering method, is based on the weighted aggregation of marks. As mark processing can be described by many rules, the method forms a fuzzy set of extra marks by the aggregation on the basis of rules, and it can also be programmed as a fuzzy system. The values of criteria, which describe alternatives, are given as marks. An extra mark is assigned to every alternative, aggregating fuzzy sets of marks which describe alternatives. Alternatives are ordered on the basis of extra marks. The mark-giving method based on examples can be generally applied for ordering.

The method is applicable if the values of criteria can be treated as marks (or if they can be transformed into them).

Let us assume $x=\{a_1,a_2,...,a_n\}$ is the final set of alternatives, and then take $K=\{k_1,k_2,...,km\}$ as the final set of fuzzy criteria. Let $g_1,g_2,...g_m$ be the weights belonging to criteria, where the maximal value of the weight is 1.

Let every $K_j$ fuzzy criteria be over x a linguistic variable ($1\leq j\leq m$), also letting $K_1=\{S_1,S_2,...,S_{p1}\}$ where $S_1$, $S_2$,…, $S_{p1}$ are the values of the linguistic variable. The functions of belonging (μ) $S_1$, $S_2$..., $S_{p1}$ to fuzzy sets are determined on the basis of marks:

$$\mu S1(x) \quad \text{supp } S1 = [0,4;1,6] \tag{1}$$

$$\mu S2(x) \quad \text{supp } S2 = [1,4;2,6] \tag{2}$$

$$\mu Sp_i(x)\ ) \quad \text{supp}Sp_i\ [p_i\text{-}0,6;p_i+0,6] \tag{3}$$

Let every function of belonging be over the sets of the same form of a triangular fuzzy set. The degree of marking (p) can be any whole number, but the exactness and possibilities of expression differ from case to case (Figure 1 represents the fuzzy sets of the criteria K, in the case p=5). The alternative $a_1$(IS i $S_n$) with $S_1$,$S_2$,... $S_{p1}$ fuzzy sets of criteria can be evaluated.

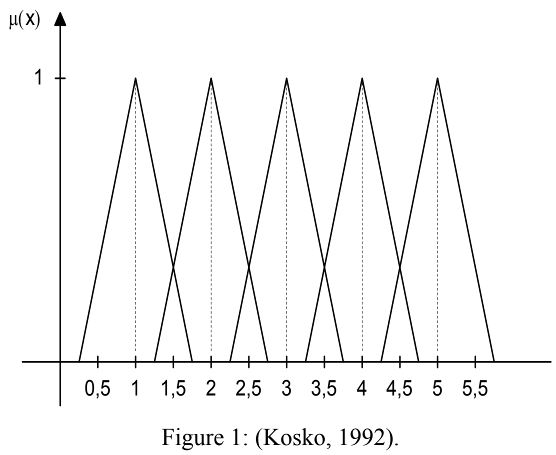


Figure 1: (Kosko, 1992).

The mark-giving method assigns every alternative $a_1$ one fuzzy set $R_i$, i.e. extra marks, which will appear in one E fuzzy set of results. The set E will enable the set $R_i$ to be compared, as well the set R not to be defined. The set E is a fuzzy set identical with the set of criteria:

$$E = \{S_1,S_2,...,S_p\} \tag{4}$$

where K = max $P_j$ (j=1,2,...m), and every R set will be formed on the basis of partly activated subsets of the E set.

Copying and aggregations of fuzzy sets are necessary for forming $R_1$ sets. In the program package of fuzzy logic, which is applicable, these operations can be performed only with the help of such program blocks which the program package treats as Kosko's FAM (fuzzy associative memories) (Kosko, 1992).

One simple FAM system copies n dimensional fuzzy sets into m dimensional with K parallel FAM rules and their simultaneous use ($A_1$, $B_1$), ($A_2$, $B_2$),… ($A_k$, $B_k$). Every A-input information activates rule of FAM system in a way every. ($A_i$, $B_i$) is FAM rule and has the form:

$$\text{IF } C = A_i \text{ THEN } D = B_i \tag{5}$$

(where C, D are linguistic variables, and $A_i$, $B_i$ are their possible values). Input information A is copied into the part of $B_1$ set, which is partly activated into $B_i$. The B set is produced from the whole FAM system, which is the weighted sum of partly activated $B_1$, $B_2$, … $B_k$ fuzzy sets:

$$B = w_1 \cdot B_1 + w_2 \cdot B_2 + ...w_k \cdot B \tag{6}$$

where $W_i$ values in the interval (0,1) designates the weights of FAM rules. One procedure of defuzzification is directly connected to the FAM system, which assigns one sole number to the B fuzzy set (Table 2). The focus point in the B set is given by the COG (Centre of Gravity) Method.

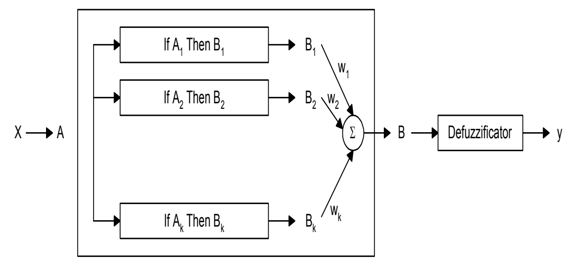


Figure 2: (Kosko, 1992).

Input data of the program block are the marks of the criteria: $o_1$, $o_2$,… $o_m$. Any $o_j$ mark of the given values of the criteria $S_1$, $S_2$,…, $S_p$. partly activates one or two neighbouring ones, and FAM rules copy these partly activated sets into the E set. The $R_i$ set is a weighted sum, even more times, of partly activated $S_1, S_2, \ldots S_{pi}$ sets.

In the course of functioning, the FAM system, one series of marks $o_1, o_2 \ldots o_m$, belonging to one $a_i$ alternative, partly activates $S_1, S_2, \ldots, S_{pj}$ sets, which are located in the part of the conditions of the FAM system. In the same way, the rule activates the same set in the part of consequences. With every copying into the set E, the given triangular number is multiplied with the CF value.

CF (Certainty factor) gives the degree of rule security by which the FAM system automatically multiplies the result of the rules. This CF value is determined by the square of criteria weights. After copying, the sets partly activated by the operator of the algebraic sum are aggregated and added, and finally, the centre of gravity of the aggregated set is formed by defuzzification.

Kosko uses the term "fuzzy associative memory" to describe how a fuzzy system works. The system activates all the rules in parallel and to a degree. Computers use direct memory. Associative memory searches the entire memory. (Kosko, 1992)

## 3 THE MARK-GIVING METHOD, JAIN'S METHOD AND YAGER'S METHOD

The formal similarities between Jain's method and the mark-giving method are used for comparing (formerly applied signs are used in comparing).

Steps of Jain's method:

1. One $R_1$ fuzzy set is formed for every $a_i$ alternative in the form:

$$R_i = \sum_{j=1}^{m} g_j \cdot r_{ij} \tag{7}$$

where $g_i$ is the fuzzy set of weights, $r_{ij}$ is the fuzzy value $K_i$ of criteria in case of a: alternative (signed operations mean the multiplication and addition of fuzzy sets).

2. A union of multiples of Ri sets is formed:

$$S = \bigcup_{i=1}^{n} \sup \ \mathrm{R_i} \tag{8}$$

and one 'maximized' M fuzzy set is defined in the set S:

$$\mu_M(r) = [r / r_{\max}]^{\beta} \tag{9}$$

with the function of belonging, where $r_{max}$=sup S and β is a natural number (the set M gives the upper limit for the values $\mu_{R_i}(r)$.

3. A fuzzy set Rio is formed from M and Ri sets with the functions belonging to:

$$\mu_{R_{i0}}(r) = \min\{\mu_{R_i}(r), \mu_M(r)\}, (r \in S) \tag{10}$$

4. One Yi value is assigned to every alternative:

$$y_i = \max \mu_{\mathrm{R_{io}}}(\mathrm{r}), (\mathrm{r} \in \mathrm{S}) \tag{11}$$

Many have criticized Jain's method as it does not give any help in forming the set M (choice β), and $Y_i$, which is assigned the alternative $a_i$, represents only one maximum value (the other ones are not taken into consideration in ordering).

Comparing to Jain's method, the steps of this method are the following:

1. Like in Jain's method, one Ri fuzzy set is formed for every ai alternative in the form:

$$R_i = \sum_{j=1}^{m} g_j \cdot r_{ij} \tag{12}$$

where the values of the weight gj can range within the interval (0,1) of real numbers, the values rij are special, and the fuzzy sets of marks are the same for every criterion (the degree of marks can be different depending on the criteria).

2-3. The method does not limit the values of functions of belonging to the sets Ri, it is not necessary to define M, nor form Rio sets. Instead, the sets Ri are compared in the mutual E set.

4. The value yi, which joins the alternative ai, representing the centre of gravity, is formed taking into consideration all the values of criteria. The value y i, shows the ordinal number of alternatives.

We can conclude that the mark-giving method, compared to Jain's method, represents a different principle of problem solving.

Taking into consideration every value of the "possibility of realization", Yager's method assigns the value $Y_i$ to the alternative $a_i$ (Philips, 1995).

$$y_i = \max \ \min (\mu_{k_j}(a_i) t_j) \qquad (13)$$

It also orders every $K_j(\leq j \leq m)$ , as well as alternatives on the basis of the value $Y_i$.

Yager's method does not always differentiate between alternatives with approximately the same weight, so it assigns the same numerical values to the groups of alternatives. With the mark-giving method we notice quite the opposite: it assigns a different numerical value to almost every alternative. According to this, the mark-giving method points more to the difference between alternatives than Yager's method.

## 4 CONCLUSIONS

The demonstrated fuzzy ordering method, which is based on marking, enables the ordering such alternatives where fuzzy criteria can be described by marks or where the values of criteria can be considered to be marks. The results are similar to results achieved by other ordering methods.

The mark-giving-method treats criteria as a fuzzy system with the rules of aggregation. It can be easy programmed by fuzzy logic software. The method is, in some points, similar to Jain's method of alternative ordering, but an ordering on the basis of weights, to assigned alternatives is a different principle in relation to Jain's method.



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