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# A MODEL FOR DETERMINING RELATIVE WEIGHTS OF DECISION-MAKERS' COMPETENCE

**Milan Nikolić, PhD in technical science**
**Zvonko Sajfert, PhD in technical science**
**University of Novi Sad, Technical faculty "Mihajlo Pupin"**
**Djure Djakovića bb, 23000 Zrenjanin**
**Serbia and Montenegro**

## ABSTRACT
*One of the typical issues in group decision-making is determining the relative importance of the decision-makers' competence. This paper presents a new model for solving this issue. The model is based on the application of the basic elements of the theory of fuzzy sets. The proposed procedure is planned in three steps. In the first step, members of a group give other members fuzzy assessments. The assessment procedure is performed in accordance with two criteria: knowledge of the decision-making problem area, and knowledge of the method which will be applied. In the second step, calculation is performed on the basis of the previously assigned fuzzy assessments. The final fuzzy assessments of each decision-maker are determined in this way. In the third step, calculation of each decision-maker's competence relative weight is performed. The calculation is performed by applying an original method. The basis for calculation in the third step are the final fuzzy assessments of each decision-maker which were obtained in the second step. The application of the proposed model provides a high degree in achieving quality and objective distribution of the relative weights among the participants of the group decision-making process.*
**Keywords:** group decision-making, decision-makers, relative weights.

## 1. INTRODUCTION
Group decision-making, (GDM), represents a special area of decision-making theory which has been developing intensively over the last decades. There are numerous references which deal with this problem area, for example: [1, 2, 3, 11, 12]. Both advantages and disadvantages of GDM can be identified by summing up these references.
The advantages of GDM are: increased resourcefulness, a larger number of approaches to a problem, generation of a larger number of alternatives, better acceptance and execution of a decision, better content and increased accuracy of a decision, better identification of mistakes by a group than by an individual, group work often stimulates its members, inclination to risk is more balanced, etc.
The disadvantages of group decision-making are: dominance of an individual, collective responsibility, pressing for a particular option, social pressure, fear of assessing a publicly expressed idea, loss of information, polarization between the members of the group, conflicts between the members of the group, existence of disposition to reach a compromise, a possibility of presence of individuals who are guided by personal interests, turning group work into uncontrolled friendly gatherings, etc.
Members of the group can have the same or different weights (importance) of their respective opinions. For that reason, in group decision-making there is the presence of the problem of determining the relative weights for all the decision-makers in a particular process. This paper presents a possible approach to this issue, that is, a mathematical apparatus for solving it. The proposed model was inspired by the methods which are presented in the references like [1, 2]. The references which deal with the area of multi-criteria decision-making and fuzzy sets were also extremely helpful [7, 10].

## 2. PRESENTATION OF THE MODEL

Determining decision-makers' competence relative weights unfolds in three steps according to the model proposed in this paper.

**Step One**

Each member of the group assigns fuzzy assessments to other members of the group. The fuzzy assessments are assigned on the basis of two criteria: knowledge of the subject problem area, and knowledge of the decision-making method which will be applied. For the time being, it is adopted that these two criteria have the same weight (0.5 each). Consequently, the average of these two assessments represents the fuzzy assessments one decision-maker has assigned to the other one. The use of the interval scale with qualitative assessments ranked into five levels is proposed before determining the fuzzy assessments. The first step can unfold 'in secrecy'.

**Step Two**

The average of the fuzzy assessments is calculated for each decision-maker (the assessments assigned by other members of the group). The following expression is used in the process:

$$FFA_{DMx} = \frac{\sum_{\substack{s=1 \\ s\neq x}}^{n_s} FA_{DMx,s}}{n_s - 1} \qquad (1)$$

in which:

$FFA_{DMx}$ – the final fuzzy assessment of the x-th decision-maker, where x = 1,2, ..., $n_s$, and in which $n_s$ is the number of DM's,

$FA_{DMx,s}$ – the fuzzy assessment assigned to the x-th decision-maker by the s-th decision-maker, where s = 1,2, ..., $n_s$, and in which $s \neq x$ (DM's do not assess themselves).

**Step Three**

Fuzzy assessments calculated in the previous step represent the final fuzzy assessments of all the decision-makers (DM's). In the third step, and based on these assessments, determining competence relative weights of all the decision-makers is carried out next. One of the numerous methods can be used in the process, for example: [4, 6, 8], and others. In [5], an original method was applied, which is outlined briefly in this paper.

**a) Determining the difference of fuzzy assessments of all the pairs of decision-makers – $AH_{DM}$ and $AL_{DM}$**

For a specified difference of fuzzy assessments within each pair of decision-makers, the corresponding assessment is assigned to the higher-ranked decision maker ($AH_{DM}$), and the lower-ranked decision-maker ($AL_{DM}$) in the pair. For the start, it is assumed that each pair has the aggregate assessment 100, in which the higher-ranked decision-maker in the pair has the assessment of 50 + X, and the lower-ranked one has the assessment 50 - X (in which X∈0,1,2,...,50). In this way, the possible combinations would be 60:40, 70:30, 95:5, and so on.

The assessment of the higher-ranked decision-maker in the pair, $AH_{DM}$, linearly and proportionally depends on the difference of fuzzy assessments (DFA) for the observed pair. The $AH_{DM}$ is calculated through the expression:

$$AH_{DM} = 50 + |DFA| \cdot 50 \qquad (2)$$

When the $AH_{DM}$ value has been calculated, the assessment of the lower-ranked decision-maker in that pair, $AL_{DM}$, is obtained by the expression:

$$AL_{DM} = 100 - AH_{DM} \qquad (3)$$

**b) Determining of the fuzzy assessment aggregates of all the pairs of decision-makers and $VH_{DM}$ and $VL_{DM}$ values**

The next is the idea that each pair has its corresponding, common assessment, which has then to be distributed to the members of the pair. For example, if the fuzzy assessments of one pair are 0.3 and 0.2, and of the other one 0.9 and 0.8, the DFA is in both cases 0.1, so that the same assessments of the higher-ranked and lower-ranked decision-makers would be formed for both pairs. However, on the whole, the second pair is considerably 'stronger', so that it seems illogical that these two pairs have the same aggregate assessment of 100. The real aggregate assessment (RAA) of the pair is obtained through the following expression:

$$RAA = 50 \cdot SFA \tag{4}$$

where is: SFA - sum of fuzzy assessments.

The final value of the higher-ranked decision-maker in the pair ($VH_{DM}$) is determined by applying the expression:

$$VH_{DM} = \frac{AH_{DM}}{100} \cdot RAA \tag{5}$$

The final value of the lower-ranked decision-maker in the pair ($VL_{DM}$) is calculated through the expression:

$$VL_{DM} = \frac{AL_{DM}}{100} \cdot RAA \tag{6}$$

**c) Determining the criteria relative weights**

The $VH_{DM}$ and $VL_{DM}$ values represent the final assessments of the decision-makers in a pair. These values are entered in a separate table similarly to the AHP method [9]. In a pair, the decision-maker who has a higher previous fuzzy assessment gets the $VH_{DM}$ value, and the decision-maker who has a lower previous fuzzy assessment gets the $VL_{DM}$ value.

## 3. AN EXAMPLE OF THE PROPOSED MODEL

There are four decision-makers–$DM_1$, $DM_2$, $DM_3$, $DM_4$ – who are taking part in the decision-making process.

In the Step One, each DM assigns a fuzzy assessment to the other members of the group. For example, let the group members assess their colleagues in the way shown in Table 1.

*Table 1 Fuzzy assessments of each DM for the other DM's*

| Criteria | $DM_1$ | | | $DM_2$ | | | $DM_3$ | | | $DM_4$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $DM_2$ | $DM_3$ | $DM_4$ | $DM_1$ | $DM_3$ | $DM_4$ | $DM_1$ | $DM_2$ | $DM_4$ | $DM_1$ | $DM_2$ | $DM_3$ |
| Knowledge of the problem (0.5) | 0.4 | 0.6 | 0.9 | 0.7 | 0.4 | 0.7 | 0.6 | 0.2 | 0.9 | 0.4 | 0.7 | 0.5 |
| Knowledge of the method (0.5) | 0.8 | 0.3 | 0.8 | 0.8 | 0.2 | 0.6 | 0.9 | 0.7 | 0.7 | 0.7 | 0.6 | 0.2 |
| Average fuzzy assessments | 0.6 | 0.45 | 0.85 | 0.75 | 0.3 | 0.65 | 0.75 | 0.45 | 0.8 | 0.55 | 0.65 | 0.35 |

In Step Two, the final fuzzy assessment for each DM is calculated:

$$FFA_{DM1} = \frac{0.75 + 0.75 + 0.55}{3} = 0.6833$$

$$FFA_{DM2} = \frac{0.6 + 0.45 + 0.65}{3} = 0.5667$$

$$FFA_{DM3} = \frac{0.45 + 0.3 + 0.35}{3} = 0.3667$$

$$FFA_{DM4} = \frac{0.85 + 0.65 + 0.8}{3} = 0.7667$$

In Step Three, the competence relative values for all the DM's are calculated. The calculation for the first two stages of the method of comparing DM's in pairs is shown in Table 2. The values from the last two columns of Table 2 (the $VH_{DM}$ and the $VL_{DM}$ values) represent the final values of the criteria assessments in a pair. These values are entered in Table 3. In the last column of Table 3, the relative weights of all the DM's for the analysed case are read: $w_1 = 0.2872$; $w_2 = 0.2301$; $w_3 = 0.1499$; $w_4 = 0.3327$. With the relative values of all the DM's determined in this way, some of the numerous methods of group decision making is entered.

*Table 2 The first two stages of the method of comparing the criteria in pairs for the given example*

| Decision-makers' final fuzzy assess. $FFA_{DMi}$ | Difference of fuzzy assess. in a pair $DFA_{i,j}$ | Initial DM's assessments in a pair | | Sum of fuzzy assess. of pair of crit. $SFA_{i,j}$ | Real aggreg. ass. of a pair of criteria $RAA_{i,j}$ | The final value of the assess. of the criteia in a pairs | |
|---|---|---|---|---|---|---|---|
| | | $AH_{DMi,j}$ | $AL_{DMi,j}$ | | | $VH_{DMi,j}$ | $VL_{DMi,j}$ |
| $FFA_{DM1}$ = 0.6833 | 0.1166 | 55.83 | 44.17 | 1.25 | 62.5 | 34.89375 | 27.60625 |
| | 0.3166 | 65.83 | 34.17 | 1.05 | 52.5 | 34.56075 | 17.93925 |
| | -0.0834 | 54.17 | 45.83 | 1.45 | 72.5 | 39.27325 | 33.22675 |
| $FFA_{DM2}$ = 0.5667 | 0.2 | 60 | 40 | 0.9334 | 46.67 | 28.002 | 18.668 |
| | -0.2 | 60 | 40 | 1.3334 | 66.67 | 40.002 | 26.668 |
| $FFA_{DM3}$ = 0.3667 | -0.4 | 70 | 30 | 1.1334 | 56.67 | 39.669 | 17.001 |
| $FFA_{DM4}$ = 0.7667 | - | - | - | - | - | - | - |

*Table 3 Calculation of the criteria relative weights for the given example*

| | $DM_1$ | $DM_2$ | $DM_3$ | $DM_4$ | Σ | $w_j$ |
|---|---|---|---|---|---|---|
| $DM_1$ | | 34.89375 | 34.56075 | 33.22675 | 102.6813 | 0.287212 |
| $DM_2$ | 27.60625 | | 28.002 | 26.668 | 82.27625 | 0.230137 |
| $DM_3$ | 17.93925 | 18.668 | | 17.001 | 53.60825 | 0.149949 |
| $DM_4$ | 39.27325 | 40.002 | 39.669 | | 118.9443 | 0.332702 |
| ΣΣ | | | | | 357.51 | **1.00000** |

## 4. CONCLUSION

The proposed method of determining the decision-makers' competence relative weights has the following characteristic features:

- members of the group assess other members of the group by fuzzy assessments,
- two criteria for assessing the decision-makers are introduced (knowledge of the decision-making problem area, and knowledge of the method),
- final fuzzy assessments of each decision-maker is determined (the DM's relative importance is determined according to them),
- calculation of the decision-makers' relative weights is performed by applying an original model.

Realization of the proposed method undoubtedly leads to the increase in the degree of objectivity in assigning the relative importance to the decision-makers in the models of group decision-making.

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