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NEW MODEL FOR DETERMINING CRITERIA WEIGHTS: LEVEL BASED WEIGHT ASSESSMENT (LBWA) MODEL

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Abstract: *This paper presents new subjective model for determining weight coefficients in multi-criteria decision-making models. The new Level Based Weight Assessment (LBWA) model enables the involvement of experts from different fields with the purpose of defining the relations between criteria and providing rational decision making. The method can be applied in practical cases in specialized decision-making support systems, as well as in alternative dispute resolutions in virtual environment. The LBWA model has several key advantages over other subjective models based on mutual comparison of criteria, which include the following: (1) the LBWA model allows the calculation of weight coefficients with small number of criteria comparisons, only n-1 comparison; (2) The algorithm of the LBWA model does not become more complex with the increase of the number of criteria, which makes it suitable for use in complex multi-criteria (MCDM) models with a large number of criteria; (3) By applying the LBWA model, optimal values of weight coefficients are obtained with simple mathematical apparatus that eliminates inconsistencies in expert preferences, which are tolerated in certain subjective models (Best Worst Method - BWM and Analytic Hierarchy Process - AHP); (4) The elasticity coefficient of the LBWA model enables, after comparing the criteria, additional corrections of the values of the weight coefficients depending on the preferences of the decision makers. This feature of the LBWA model enables sensitivity analysis of the MCDM model by analyzing the effects of variations in the values of the weights of criteria on final decision.*

Key words: *multi-criteria decision making, criteria weights; LBWA model.*

1. Introduction

Determining weights of criteria is one of the key problems arising in the models of multi-criteria analysis to which the problem being solved in this paper belongs to. The

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absence of unique precise definition of the notion of the weight of criteria and the problem of selecting appropriate method for determining weights of criteria in specific decision-making situation are among the most important factors that make the problem of determining weights of criteria significantly more complex. Taking into account the fact that the weights of criteria can significantly influence the outcome of the decision-making process, it is clear that special attention must be paid to the models for determining weights of criteria. Most authors suggest the division of models for determining weights of criteria on subjective and objective models (Zhu et al., 2015).

Subjective approaches reflect subjective thinking and intuition of a decision maker. In such approach the weights of criteria are determined on the basis of information obtained from the decision makers or from the experts involved in the decision-making process. Traditional methods of determining weights of criteria include tradeoff method (Keeney & Raiffa, 1976), proportional (ratio) method, Swing method (Weber et al., 1988) and conjoint method (Green & Srinivasan, 1990), Analytic Hierarchy Process model (AHP) (Saaty, 1980), SMART method (the Simple Multi Attribute Rating Technique) (Edwards & Barron, 1994), MACBETH method (Measuring Attractiveness by Categorical Based Evaluation Technique) (Bana e Costa & Vansnick, 1994), Direct point allocation method (Poyhonen & Hamalainen, 2001), Ratio or direct significance weighting method (Weber & Borcherding, 1993), Resistance to change method (Rogers & Bruen, 1998), AHP method (Saaty, 1980), WLS method (Weighted Lest Square) (Graham, 1987) and FPP method (the Fuzzy Preference Programming method) (Mikhailov, 2000). Recent subjective methods include multipurpose linear programming (Costa & Climaco, 1999), linear programming (Mousseau et al., 2000), DEMATEL (DEcision MAking Trial and Evaluation Laboratory) method (Gabus & Fontela, 1972), SWARA (Step-wise Weight Assessment Ratio Analysis) method (Valipour et al., 2017), BWM (Best Worst Method) (Rezaei, 2015) and FUCOM (FUll COnsistency Method) (Pamučar et al., 2018).

On the other hand, objective approaches ignore decision makers' opinion and are established on determining weights of criteria based on the information contained in decision-making matrix using certain mathematical models. Among the most known objective methods are the following: entropy method (Shannon & Weaver, 1947), CRITIC method (CRiteria significance Through Intercriteria Correlation), (Diakoulaki, et al, 1995) and FANMA method whose name was derived from the names of the authors of the method (Srđević et al., 2003). According to Zhu et al. (2015) the most commonly used models for determining weight coefficients of criteria are subjective models with pair comparisons of criteria. In the models with pair comparisons, decision makers compare each criterion with other criteria and determine the level of preferences for each pair of criteria. As a support in determining the size of the preference of a criterion over another one it is used the ordinal scale. The most commonly used methods based on pair comparisons include (Zavadskas et al., 2016) AHP method, BWM and DEMATEL method. Zavadskas et al. (2016) have shown in their research that the AHP method is the most commonly used method for determining weights of criteria in the literature. However, in the AHP method needs to be performed $n(n-1)/2$ comparison in pairs of criteria. A large number of comparisons makes the application of the model more complex, especially in cases of a large number of criteria. According to Zhu et al. (2015) in the AHP method it is almost impossible to perform fully consistent comparisons in pairs with over nine criteria. This problem is often overcome by dividing the criteria into subcriteria, which further makes the model more complex.

The DEMATEL method is also used in numerous studies, but its main disadvantage is a large number of comparisons in pairs which is $n(n-1)$. Therefore, the DEMATEL method is mostly used to determine the interaction between the criteria and the relationship diagram (Parezanovic et al., 2019).

The method that has become widely used in a short time is the BWM method. Its biggest advantage compared to the AHP model is smaller number of pair comparisons ($2n-3$). However, a large number of comparisons in pairs of criteria, defining the limitations for solving nonlinear model and solving non-linear model make the application of the BWM significantly more complex. Therefore, this model is still unacceptable to a large number of researchers.

Taking into consideration the stated deficiencies of the presented models, the need arises to provide for a method whose algorithm requires small number of comparisons in pairs of criteria and which has rational and logical mathematical algorithm. Starting from this point, a Level Based Weight Assessment model (LBWA) has been developed. The first goal of the paper is to present the new model for determining weights of criteria which requires small number of criteria comparisons, just $n-1$ comparison. The second goal of the paper is to present practical model for solving complex MCDM models, regardless of the number of evaluation criteria. One of significant characteristics of the LBWA model is to maintain simple algorithm regardless of the complexity of the model. The third goal is to define a model which allows the calculation of reliable values of weight coefficients of criteria that contribute to rational judgment. The fourth goal of the paper is the development of a model that can be easily presented/explained to decision-makers, and therefore easily implemented in solving practical problems.

The remaining part of the paper is organized in the following way. In the second section of the paper, the LBWA model algorithm is presented. In the third section of the paper, the LBWA model is tested with two examples from the literature. The fourth chapter provides concluding observations and directions for future research.

2. Level Based Weight Assessment (LBWA) model

Let us consider a multi-criteria model with *n* criteria $S=\{C_1,C_2,\ldots,C_n\}$. Suppose that weight coefficients associated to these criteria are to be determined, i.e., they are not given in advance. In the following part it is presented the process of obtaining the weight coefficients of criteria by applying the LBWA model:

Step 1. Determining the most important criterion from the set of criteria $S=\{C_1,C_2,\ldots,C_n\}$. Let the decision maker determine the most important criterion, i.e., let the criterion C_1 be the criterion in the set of criteria $S=\{C_1,C_2,\ldots,C_n\}$ that is the most significant for the decision-making process.

Step 2. Grouping criteria by levels of significance. Let the decision maker establish subsets of criteria in the following way:

Level S_1*:* At the level S_1 group the criteria from the set *S* whose significance is equal to the significance of the criterion C_1 or up to twice as less as the significance of the criterion C_1;

Level S_2*:* At the level S_2 group the criteria from the set S whose significance is exactly twice as less as the significance of the criterion C_1 or up to three times as less as the significance of the criterion C_1;

Level S_3*:* At the level S_3 group the criteria from the set *S* whose significance is exactly three times as less as the significance of the criterion C_1 or up to four times as less as the significance of the criterion C_1 ;

...

Level S_k *:* At the level S_k group the criteria from the set *S* whose significance is exactly k times as less as the significance of the criterion C_1 or up to $k+1$ as less as the significance of the criterion C_1 .

By applying the rules presented above, the decision maker establishes rough classification of the observed criteria, i.e., groups the criteria according to the levels of significance. If the significance of the criterion C_j is denoted by $s(C_j)$, where $j \in \{1,2,\ldots,n\}$, then we have $S = S_1 \cup S_2 \cup \cdots \cup S_k$, where for every level $i \in \{1,2,\ldots,k\}$, the following applies

$$S_i = \{C_{i_1}, C_{i_2}, \ldots, C_{i_s}\} = \{C_j \in S : i \le s(C_j) < i+1\} \tag{1}$$

Also, for each $p,q \in \{1,2,\ldots,k\}$ such that $p \ne q$ holds $S_p \cap S_q = \varnothing$. Thus, in this way is well defined partition of the set of criteria *S*.

Step 3. Within the formed subsets (levels) of the influence of the criteria it is performed the comparison of criteria by their significance. Each criterion $C_{i_p} \in S_i$ in the subset $S_i = \{C_{i_1}, C_{i_2}, \ldots, C_{i_s}\}$ is assigned with an integer $I_{i_p} \in \{0,1,\ldots,r\}$ such that the most important criterion C_1 is assigned with $I_1 = 0$, and if C_{i_p} is more significant than C_{i_q} then $I_p < I_q$, and if C_{i_p} is equivalent to C_{i_q} then $I_p = I_q$. Where the maximum value on the scale for the comparison of criteria is defined by applying the expression (2)

$$r = \max\{|S_1|, |S_2|, \ldots, |S_k|\} \tag{2}$$

Step 4. Based on the defined maximum value of the scale for the comparison of criteria (*r*), the equation (2), it is defined the elasticity coefficient $r_0 \in N$ (where *N* presents the set of real numbers) which should meet the requirement where $r_0 > r$, $r = \max\{|S_1|, |S_2|, \ldots, |S_k|\}$.

Step 5. Calculation of the influence function of the criteria. The influence function $f : S \to R$ is defined in the following way. For every criterion $C_{i_p} \in S_i$ can be defined the influence function of the criterion

$$f(C_{i_p}) = \frac{r_0}{i \cdot r_0 + I_{i_p}} \tag{3}$$

where *i* presents the number of the level/subset in which is classified the criterion, r_0 presents the elasticity coefficient, while $I_{i_p} \in \{0,1,\ldots,r\}$ presents the value assigned to the criterion C_{i_p} within the observed level.

Step 6. Calculation of the optimum values of the weight coefficients of criteria. By applying the equation (4) it is calculated the weight coefficient of the most significant criterion:

$$w_1 = \frac{1}{1 + f(C_2) + \cdots + f(C_n)} \tag{4}$$

The values of the weight coefficients of the remaining criteria are obtained by applying the expression (5)

$$w_j = f(C_j) \cdot w_1 \quad (5)$$

where $j = 2,3,\ldots,n$, and n present total number of criteria.

3. Application of the LBWA model

In the following section it is presented the application of the LBWA model in determining weight coefficients of criteria in the multi-criteria problems discussed in the literature. In the first section, the multicriteria problem of prioritizing railway level crossings for safety improvements is presented (Ćirović & Pamučar et al., 2013), while in the second section the problem of determining weight coefficients in evaluating the performance of suppliers is considered (Chatterjee et al., 2018).

Example 1. Determination of the weight coefficients of criteria for the evaluation of level crossings

In the research conducted by Ćirović and Pamučar (2013), eight criteria were identified that influence the selection of the level crossings for the installation of necessary equipment for increasing traffic safety at the observed crossing: C1 - Rail traffic frequency at the observed crossing, C2 - Road traffic frequency at the observed crossing, C3 - Number of tracks at the observed crossing, C4 - Maximum allowed train speeds at the crossing chainage, C5 - Rail and road crossing angle, C6 - Number of extraordinary events at the observed crossing in the past year, C7 - Sight distance of the observed crossing from the aspect of road traffic and C8 - Investment value of the activities in terms of the width of the crossing.

The following section presents the application of the LBWA model in calculating the weight coefficients of criteria for the evaluation of level crossings:

Step 1. Determining the most important criterion from the set of criteria $S = \{C_1, C_2, \ldots, C_8\}$. In the defined problem, the criterion C_2 is selected as the most important/influential criterion.

Step 2. Grouping criteria by levels of significance. In accordance with the preferences of the decision makers, the criteria are grouped in the following subsets/levels:

Level S_1: the criteria C_1, C_3, C_5, C_6 and C_7 are up to twice as less significant as the criterion C_2 and

Level S_2: (2) the criteria C_4 and C_8 are between twice and three times less significant than the criterion C_2. Than, based on the preferences mentioned the criteria can be grouped in the following subsets/levels:

$S_1 = \{C_2, C_1, C_3, C_5, C_6, C_7\}$,

$S_2 = \{C_4, C_8\}$.

Step 3. Within the formed subsets/levels of criteria influence, a comparison of the criteria with respect to their significance is made. Based on the equation (2), it is defined the maximum value of the scale for comparing the criteria

$$\left.\begin{matrix} S_1 = \{C_2, C_1, C_3, C_5, C_6, C_7\} \\ S_2 = \{C_4, C_8\} \end{matrix}\right\} \Rightarrow r = \max\{|S_1|, |S_2|\} = 6$$

On the basis of the obtained value can be concluded that the scale for comparing the criteria ranges in the interval $I_{i_p} \in \{0,1,\ldots,6\}$. Applying previously defined relations can be performed the comparison of criteria within each individual set of criteria:

Level S_1: Based on the preferences of the decision makers, the following relations can be defined: $I_2 = 0$, $I_5 = 2$, $I_7 = 3$, $I_6 = 4$, $I_1 = 4$, $I_3 = 5$.

Considering that the criterion C_2 has the largest influence, its value assigned is $I_1 = 0$. To the remaining criteria are assigned the values from the predefined scale $I_{i_p} \in \{0,1,\ldots,6\}$, under the condition where if the criterion C_{i_p} has higher weight coefficient than the criterion C_{i_q}, then the condition $I_p < I_q$ is met.

Level S_2: Based on the preferences of the decision makers, the following relations can be defined: $I_8 = 1$ i $I_4 = 2$.

Step 4. Based on the defined maximum value of the scale for comparing the criteria $r = 6$, it is defined the elasticity coefficient where $r_0 > r$, respectively, $r_0 > 7$.

Step 5. Defining the influence function of the criteria. If it is known that $r_0 > 6$, it is arbitrarily determined the value $r_0 = 7$. By applying the equation (3) the influence functions of the criteria are calculated.

$$f(C_2) = \frac{7}{1\cdot 7+0} = \frac{7}{7} = 1;\ f(C_5) = \frac{7}{1\cdot 7+2} = \frac{7}{9};\ f(C_7) = \frac{7}{1\cdot 7+3} = \frac{7}{10};\ f(C_6) = \frac{7}{1\cdot 7+4} = \frac{7}{11};$$

$$f(C_1) = \frac{7}{1\cdot 7+4} = \frac{7}{11};\ f(C_3) = \frac{7}{1\cdot 7+5} = \frac{7}{12};\ f(C_8) = \frac{7}{2\cdot 7+1} = \frac{7}{15};\ f(C_4) = \frac{7}{2\cdot 7+2} = \frac{7}{16}.$$

Step 6. Calculation of the optimum values of the weight coefficients of criteria. By applying the equation (4) it is calculated the weight coefficient of the most influential criterion

$$w_2 = \frac{1}{1+0.778+0.700+\ldots+0.438} = 0.191$$

The values of the weight coefficients of the remaining criteria are obtained by applying the equation (5). Therefore, for the criterion C_1 it is obtained the weight coefficient $w_1 = f(C_1)\cdot w_2 = 0.636\cdot 0.191 = 0.121$. In the similar way are obtained the values of the weight coefficients of the remaining criteria which meet the condition where $\sum_{j=1}^{n} w_j = 1$.

$$w_3 = f(C_3)\cdot w_2 = 0.583\cdot 0.191 = 0.111;$$
$$w_4 = f(C_4)\cdot w_2 = 0.438\cdot 0.191 = 0.084;$$
$$w_5 = f(C_5)\cdot w_2 = 0.778\cdot 0.191 = 0.148;$$
$$w_7 = f(C_7)\cdot w_2 = 0.700\cdot 0.191 = 0.134;$$
$$w_6 = f(C_6)\cdot w_2 = 0.636\cdot 0.191 = 0.121;$$
$$w_8 = f(C_8)\cdot w_2 = 0.467\cdot 0.191 = 0.089.$$

Finally, it is obtained the vector of the weight coefficients

$$w_j = (0.121, 0.191, 0.111, 0.084, 0.148, 0.121, 0.134, 0.089)^T.$$

By comparing the values of the weight coefficients obtained using the LBWA model with the weight coefficient values from the study made by Ćirović and Pamučar (2013), it can be noted that almost identical weight values are obtained, which confirms successful validation of the LBWA model.

Considering that the value of the elasticity coefficient r_0 in this example is defined arbitrarily as $r_0 = 7$, in the following part (Figure 1) is presented the influence of the value r_0 to the change of the values of the weight coefficients of criteria.

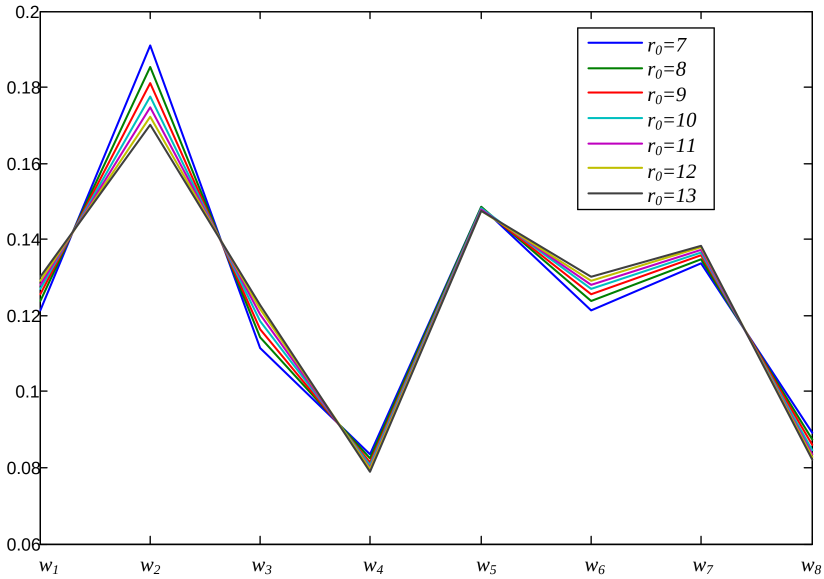

Figure 1. Influence of the value of r_0 to the change of the weight coefficients values

From the Figure 1 it can be noted that the parameter r_0 in certain measure can cause smaller changes of the weight coefficients values. The parameter r_0 allows decision makers to make fine adjustments of the weight coefficients values in accordance with their own preferences. The authors recommend the initial values of the weight coefficients to be defined on the basis of the value of the parameter $r_0 = r + 1$. After the definition of initial values, decision makers can make additional adjustment of weight coefficients by changing the parameter r_0.

Example 2. Determination of the weight coefficients of criteria in the evaluation of the work of advisors in the transport of dangerous goods

In the research carried out by Pamučar et al. (2019), nine criteria were identified for the evaluation of the work of advisors in the transport of dangerous goods: C1 - Knowledge of regulations and professional development, C2 - Analytic processing of established requirements, C3 - Quality of proposed measures, C4 - Level of realization of the proposed measures, C5 - Quality of professional training of employees, C6 - Response method in emergency situations, C7 - Document preparation, C8 - Method of solving professional questions and C9 - Activity in professional institutions.
The weight coefficients of the criteria for evaluating the work of advisors in the transport of dangerous goods are defined using the LBWA model:

Step 1. Determining the most important criterion from the set of criteria $S = \{C_1, C_2, \ldots, C_9\}$. As the most significant/influential criterion, it is selected the criterion C_5 within the defined problem.

Step 2. Grouping criteria by levels of significance. In accordance with the preferences of the decision makers, the criteria are grouped in the following subsets/levels:

Level S_1: The criteria C_1, C_8 and C_9 are up to twice as less important as the criterion C_5,

Level S_2: The criteria C_3 and C_4 are between twice or three times as less important as the criterion C_5

Level S_4: The criterion C_6 is between four or five times as less important as the criterion C_5,

Level S_7: The criteria C_2 and C_7 are between seven or eight times as less important as the criterion C_5

Then, based on the mentioned preferences of the decision makers the criteria can be grouped in the following subsets/levels:

$S_1 = \{C_1, C_5, C_8, C_9\}$,
$S_2 = \{C_3, C_4\}$,
$S_3 = \varnothing$,
$S_4 = \{C_6\}$,
$S_5 = S_6 = \varnothing$,
$S_7 = \{C_2, C_7\}$.

Step 3. Based on the equation (2), it is defined the maximum value of the scale for the comparison of criteria

$$\left.\begin{aligned} &S_1 = \{C_1, C_5, C_8, C_9\}, \\ &S_2 = \{C_3, C_4\}, \\ &S_3 = \varnothing, \\ &S_4 = \{C_6\}, \\ &S_5 = S_6 = \varnothing, \\ &S_7 = \{C_2, C_7\}. \end{aligned}\right\} \Rightarrow r = \max\{|S_1|, |S_2|, |S_4|, |S_7|\} = 4$$

Based on the maximum value of the scale for comparison, it can be concluded that the scale for comparing the criteria ranges in the interval $I_{i_p} \in \{0, 1, \ldots, 4\}$. Based on the scale and the pre-defined set of criteria, it can be performed the comparison of criteria within each individual set:

Level S_1: Based on the preferences of the decision makers, the following relation are defined: $I_5 = 0$, $I_8 = 1$, $I_9 = 2$ and $I_1 = 4$.

Level S_2: Within the set S_2 the following relations are defined: $I_3 = 1$ and $I_4 = 2$.

Level S_4: Within the set S_4 the following relation is defined $I_6 = 2$.

Level S_7: Within the set S_7 the following relations are defined: $I_2 = 1$ and $I_7 = 3$.

Step 4. Based on the defined maximum value of the scale for the comparison of criteria $r = 4$, it is defined the elasticity coefficient such that $r_0 > r$, respectively, $r_0 > 4$.

Step 5. Defining the influence function of the criteria. If it is known that $r_0 > 4$, arbitrarily is determined the value $r_0 = 5$. By applying the equation (3) the influence functions of the criteria are calculated.

$$f(C_5)=\frac{5}{1\cdot 5+0}=1;\; f(C_8)=\frac{5}{1\cdot 5+1}=\frac{5}{6};\; f(C_9)=\frac{5}{1\cdot 5+2}=\frac{5}{7};$$
$$f(C_1)=\frac{5}{1\cdot 5+4}=\frac{5}{9};\; f(C_3)=\frac{5}{2\cdot 5+1}=\frac{5}{11};\; f(C_4)=\frac{5}{2\cdot 5+2}=\frac{5}{12};$$
$$f(C_6)=\frac{5}{4\cdot 5+2}=\frac{5}{22};\; f(C_2)=\frac{5}{7\cdot 5+1}=\frac{5}{36};\; f(C_7)=\frac{5}{7\cdot 5+3}=\frac{5}{38}.$$

Step 6. Calculation of the optimum values of the weight coefficients of criteria. By applying the equation (4) it is calculated the value of the weight coefficient of the most influential criterion

$$w_5=\frac{1}{1+0.833+0.714+...+0.132}=0.224$$

By applying the equation (5) are obtained the values of the weight coefficients of the remaining criteria:

$$w_8=f(C_8)\cdot w_5=0.883\cdot 0.224=0.186;\quad w_4=f(C_4)\cdot w_5=0.417\cdot 0.224=0.093;$$
$$w_9=f(C_9)\cdot w_5=0.714\cdot 0.224=0.160;\quad w_6=f(C_6)\cdot w_5=0.227\cdot 0.224=0.051;$$
$$w_1=f(C_1)\cdot w_5=0.556\cdot 0.224=0.124;\quad w_2=f(C_2)\cdot w_5=0.139\cdot 0.224=0.031;$$
$$w_3=f(C_3)\cdot w_5=0.455\cdot 0.224=0.102;\quad w_7=f(C_7)\cdot w_5=0.132\cdot 0.224=0.029.$$

Finally, the vector of the weight coefficients is obtained

$$w_j=(0.124;0.03;0.102;0.093;0.224;0.051;0.029;0.186;0.160)^T.$$

In this example, the value of the elasticity coefficient r_0 is arbitrarily defined as $r_0=5$, and in the following part (Figure 2) is presented the influence of the value r_0 to the change of the weight coefficients of criteria.

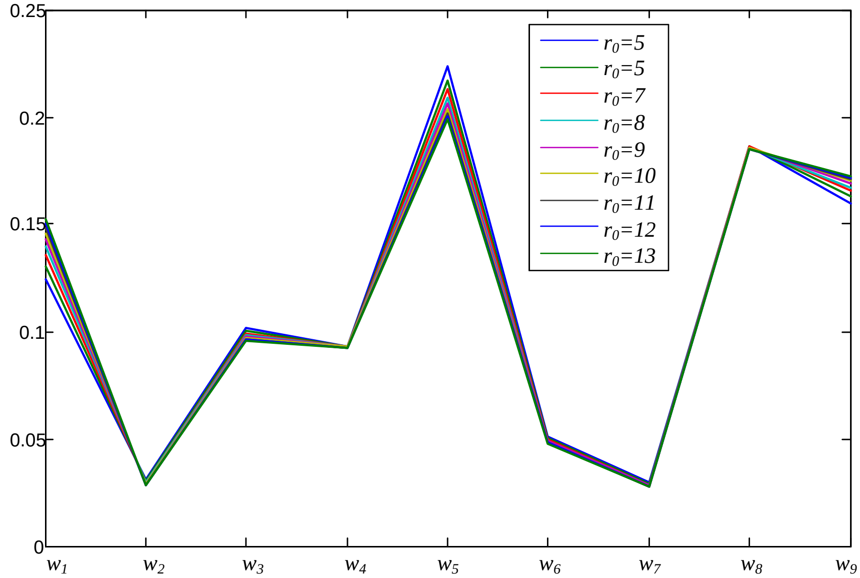

Figure 2. Influence of the value r_0 to the change of the weight coefficients

From the Figure 2 can be observed that the changes in the elasticity coefficient lead to minor changes in the weight coefficients of criteria. This feature of the LBWA model allows additional adjustment of the weight coefficients in accordance with the decision makers preferences.

4. Discussion of results and conclusion

Literature review and the analysis of the models for determining weight coefficients of criteria present in the literature so far clearly indicate the need for the development of a new credible model for determining weight coefficients of criteria. Therefore, in this paper is presented a new model, the LBWA model, which is characterized by simple and rational mathematical algorithm. The results of this study have shown that the LBWA model allows obtaining credible and reliable weight coefficients that contribute to rational judgment, and thus to obtaining credible results in decision-making process.

Based on the results presented can be outlined the following advantages of the LBWA model: (1) The LBWA model allows the calculation of weight coefficients with small number of criteria comparisons, only $n-1$ comparison; (2) The LBWA model algorithm does not become more complex with the increase of the number of criteria, which makes it suitable for use in complex MCDM models with a larger number of evaluation criteria; (3) The LBWA model allows decision makers to present their preferences through logical algorithm when prioritizing criteria. Using the LBWA model, optimal values of weight coefficients are obtained with simple mathematical apparatus that eliminates inconsistencies in expert preferences, which are tolerated in certain subjective models (BWM and AHP); (4) Flexibility of the model in terms of using all the values from the predefined scale, i.e., it is not limited to integer values from the defined interval.

In addition to the mentioned advantages, it is necessary to emphasize the flexibility of the LBWA model in terms of additional corrections of weight coefficients values by the elasticity coefficient (r_0). The elasticity coefficient allows decision makers to further adjust weight coefficients values in accordance with their own preferences. In addition, the elasticity coefficient allows the analysis of the robustness of the MCDM model by defining the effect of the change of the criteria weight coefficients on the final decision.

In order to approach users and exploit all the advantages of the LBWA model, the need for software development and implementation in real-world applications is imposed. One of the directions of future research should cover the extension of the algorithm for the application in group decision making. Also, one of the directions of future research should be the extension of the LBWA model using different uncertainty theories (neutrosophic sets, fuzzy sets, rough numbers, gray theory, etc.). The implementation of the LBWA model in uncertain environment will enable the processing of expert preferences, even in cases where the information about the considered problem are partially accessible or even very little known. This would enable more objective expression of the decision makers' preferences by respecting subjectivity and lack of information on certain phenomena.

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