A FRAMEWORK FOR THE QUALITY CONTROL MANAGER SELECTION BASED ON THE PIPRECIA AND WS PLP METHODS

Gabrijela Popović[1]

DOI: https://doi.org/10.31410/EMAN.S.P.2019.33

Abstract: *Increasing demand for quality products has an impact on the rising significance of the role of the quality control manager. Recruiting a new quality control manager and his/her selection amongst a greater number of the candidates who have applied is a very complex task. There are a significant number of the criteria that a candidate should meet, which on their part affect the final ranking and selection. It is a very delicate decision because there is a very thin line separating a good choice from a bad one. With the aim of facilitating the process of the selection of a quality control manager, the application of the framework based on the PIPRECIA (PIvot Pairwise RElative Criteria Importance Assessment) and WS PLP (Weighted Sum method, based on the decision-maker's Preferred Levels of Performances) methods is proposed in this paper. The applicability of the proposed framework is presented by a numerical example, where three decision-makers evaluate six candidates against the five evaluation criteria.*

Keywords: *WS PLP method, PIPRECIA method, quality control manager, selection.*

1. INTRODUCTION

In modern business conditions, when companies are faced with extremely strong competition, the key success item is the quality personnel who invest their knowledge, skills and energy in the achievement of the intended results. In that sense, the evaluation and selection of such personnel, who will contribute to its further development and progress, is a very important and complex task for companies to do. The process of the evaluation and selection of a candidate does not only acknowledge the considered candidate's existing performances, but it also acknowledges how he/she will behave in the future and how he/she will contribute to the company's future business operations.

Beside educated and competent personnel, the fact that significantly influences a company's performances and rating is certainly the quality of the product or service offered to its consumers. Companies always tend to completely meet their consumers' expectations and, if possible, even exceed them. Different processes are conducted within a particular company, but the quality control process is extremely important because it ensures that the final product is in accordance with consumers' expressed preferences [1]. So, it is clear that the selection of a quality control manager is a critical issue because of the fact that his/her knowledge, abilities and competencies are what the final result, i.e. the product to be offered to consumers, depends on. Because of that, different criteria should be taken into account during the process of the selection of a quality control manager in order to promulgate the best possible decision, and Multiple Criteria Decision-Making methods (MCDM) are a useful help in looking for the optimal choice.

MCDM methods are a part of operational research and management science, which has especially been increasingly popular in the last few decades. Over time, different methods have been proposed, such as the widely known: SAW or WS [2], AHP [3], TOPSIS [4], as well as the

1 Faculty of Management in Zaječar, Park šuma Kraljevica bb, 19000 Zaječar, Serbia

newly-introduced methods, such as: SWARA [5], WASPAS [6] and EDAS [7]. Apart from the previously mentioned methods, there are many more that are possible to apply in many business fields and in solving real-life problems. Additionally, appropriate extensions of the MCDM methods are proposed by introducing fuzzy, grey or rough numbers.

Various MCDM methods are applied in the case of personnel selection. For instance, Karabasevic et al. used a combination of the SWARA and ARAS methods, as well as the SWARA and WASPAS methods [8], [9]. Appropriate extensions for resolving the issue of personnel selection are proposed, the paper by Afshari et al., which provides an overview of fuzzy decision-making applied in the mentioned area, being a good example [10]. The selection of an adequate project manager is a very interesting topic as well [11], [12]. Zolfani et al. used the AHP-COPRAS-G methods with the aim of selecting an adequate quality control manager [1]. For that purpose, a framework based on the PIPRECIA [13] and WS PLP [14] methods is proposed in this paper. In order to demonstrate the usability of the proposed framework, the rest of the paper is organized as follows: in the second section, the proposed framework is explained; in the third section, an illustrative numerical example is given; in the end, the conclusion is presented.

2. THE PROPOSED FRAMEWORK

In this section, a detailed explanation of the PIPRECIA and WS PLP methods, which are the basis of the proposed framework for the selection of the optimal candidate who will perform the role of the quality control manager, is given. The PIPRECIA method is proposed for the purpose of determining the significance of the evaluation criteria, whereas the WS PLP method is used for the purpose of the final ranking and selection of the optimal alternative, i.e. the optimal candidate.

2.1. THE PIPRECIA METHOD

In the MCDM methods application process, defining criteria weights is a very important stage. For that purpose, different MCDM methods are used, such as: the AHP method [3], the entropy method [15], the SWARA method [5] and the KEMIRA method [16]. In this paper, the utilization of the PIPRECIA method, introduced by Stanujkic et al., is proposed [13]. The given method is very useful to apply in the conditions when the decision-making process involves a larger number of participants, when it could be applied through the following steps.

***Step* 1**. Determine the evaluation criteria that will be the basis for carrying out the decision-making process.

***Step* 2**. Detect the relative significance s_j, starting from the second criterion in the following manner:

$$s_j = \begin{Bmatrix} >1 & when & C_j \succ C_{j-1} \\ 1 & when & C_j = C_{j-1} \\ <1 & when & C_j \prec C_{j-1} \end{Bmatrix}. \tag{1}$$

Step **3**. Define the coefficient k_j as follows:

$$k_j = \begin{Bmatrix} 1 & j = 1 \\ 2 - s_j & j > 1 \end{Bmatrix}. \tag{2}$$

Step **4**. Determine the recalculated value q_j by applying the following Eq.:

$$q_j = \begin{Bmatrix} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{Bmatrix}. \tag{3}$$

Step **5**. Distinguish the relative weights of the estimated criteria in the following manner:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}, \tag{4}$$

where w_j is the relative weight of the criterion *j*.

2.2. THE WS PLP METHOD

The WS PLP method proposed by Stanujkic and Zavadskas [14] represents a modified and improved version of the widely known WS method. It enables the acknowledgement of the decision-maker's (hereinafter referred to as the *DM*) expectations to a higher degree by introducing preferred performance ratings, namely *ppr* values. So, the *DM* determines in advance the criteria values that reflect his/her requirements, and available alternatives are estimated relative to these values. This method enables making a clear distinction between the alternatives with the best performances among all from that which best fits in the set preconditions expressed through the *ppr* values. Besides, during the procedure, the alternatives that are not acceptable, i.e. those not matching the given limits, are excluded from the further evaluation process. In that manner, a set of available alternatives are transformed into a set of appropriate alternatives, and a selection is performed out of the second set.

This method is considered appropriate to apply in the process of the selection of a quality control manager since the *DM*s involved in the procedure mainly know what their expectations are in connection with the candidates' competences; by applying the WS PLP method, they can immediately express them and estimate the candidates according to their requirements. Also, the given method provides such *DM*s with a possibility of deciding whether they want to give advantage to the candidate who is the best of all the other candidates, or to the candidate who better meets the given ppr values. Sometimes, some alternatives have a good ranking position because they have good performances relative to one or only a few criteria, while in respect to the other criteria they may even be worse. The application of the WS PLP method exactly enables the minimization of the occurrence of a situation of this kind because it clearly indicates whether the given alternative has a better position because some parameters are extremely good, whereas the other are quite bad, thus quite reducing the possibility of making bad and inadequate decisions.

The computational procedure related to the application of the WS PLP method is as follows:

***Step* 1**. A decision matrix containing evaluation criteria, criteria weights and the alternatives that will be estimated is created.

***Step* 2.** *DM*s determine the *ppr* values according to their preferences, which depicts the elements of the virtual alternative $A_0=\{x_{01}, x_{02}, \dots x_{0n}\}$. In case the *DM* does not define the *ppr* value of any criterion, it is determined as follows:

$$x_{0j} = \begin{cases} \max_i x_{ij} \,|\, j \in \Omega_{\max} \\ \min_i x_{ij} \,|\, j \in \Omega_{\min} \end{cases}, \tag{5}$$

where x_{0j} is the optimal *ppr* of the criterion *j*; $\Omega_{\max}$ is a set of benefit criteria and $\Omega_{\min}$ is a set of cost criteria.

***Step* 3.** The normalization procedure is performed by applying Eqs (6) and (7):

$$r_{ij} = \frac{x_{ij} - x_j^*}{x_j^+ - x_j^-}; j \in \Omega_{\max}, \text{ and} \tag{6}$$

$$r_{ij} = \frac{x_j^* - x_{ij}}{x_j^+ - x_j^-}; j \in \Omega_{\min}, \tag{7}$$

where r_{ij} denotes the normalized performance rating of the alternative *i* with respect to the criterion *j*, x^*_j denotes the *ppr* value of the criterion *j*, and x^+_j and x^-_j are the highest and the lowest performance ratings of the criterion *j*, respectively.

***Step* 4.** The overall performance rating for each alternative is calculated by the following Eqs:

$$S_i = \sum_{j=1}^{n} w_j \cdot r_{ij}, \tag{8}$$

where S_i is the overall performance rating of the alternative *i*, and $S_i \in [0,1]$.

The calculation should be continued through the following steps in case two or more alternatives fulfil the condition $S_i>0$. Otherwise, the procedure ends in this step and the best choice is the alternative whose S_i is the biggest.

***Step* 5.** For the alternatives that meet the condition $S_i>0$, the compensation coefficient should be determined by applying the following Eqs.:

$$c_i = \lambda d_i^{\max} + (1-\lambda)\,\overline{S}_i^+, \tag{9}$$

where:

$$d_i^{\max} = \max_i d_i = \max_i r_{ij} w_j, \tag{10}$$

$$\overline{S}_i^+ = \frac{S_i^+}{n_i^+}, \tag{11}$$

where d_i^{max} denotes the maximum weighted normalized distance of the alternative *i* relative to the *ppr* values of all the criteria, so that $r_{ij}>0$, $\overline{S}_i^+$ is the average performance ratings gained on the basis of the criteria, so that $r_{ij}>0$, n_i^+ represents the number of the criteria of the alternative *i*, so that $r_{ij}>0$, λ is the coefficient ($\lambda=[0,1]$) and most often it is set at 0.5.

***Step* 6.** The calculation of the adjusted performance rating should be performed for all the alternatives in which S_i by using Eq. (12):

$$S'_i = \sum_{j=1}^{n} w_j r_{ij} - \gamma c_i , \tag{12}$$

where S'_i denotes the adjusted overall performance rating of the alternative *i*, c_i is the compensation coefficient ($c_i>0$), and γ is the coefficient ($\lambda=[0,1]$).

***Step* 7.** The highest S'_i value belongs to the most acceptable alternative ranked as the first and the remaining alternatives are ranked in ascending order according to their S'_i values.

3. AN ILLUSTRATIVE NUMERICAL EXAMPLE

With the aim of implying the usability and applicability of the proposed framework for the selection of a quality control manager, three *DM*s were involved in the evaluation of the six potential candidates (A_1, A_2, A_3, A_4, A_5 and A_6) for the position in industry production. Every candidate involved in the selection process had different performances relative to his/her experience, education and other characteristics. The *DM*s, who are experts in the field of human resources and quality management, estimated the candidates concerned according to the previously defined criteria. These evaluation criteria are given in Table 1.

Criteria		*Description*
C_1	Familiarity with the product and the materials used	Appropriate knowledge of the product performances and the characteristics of the materials used
C_2	Education and experience	Appropriate formal education and a suitable period of time spent in the same position in previous workplaces
C_3	Familiarity with administration	The knowledge of the laws, regulations and procedures relative to the given business field
C_4	Flexibility	The ability to react fast to changes in the environment, as well as in the company
C_5	Risk assessment	The ability to successfully anticipate and manage risk
C_6	Teamwork	The ability to connect and work with other associates

Table 1: Evaluation criteria [1]

In the paper by Zolfani et al. [1], apart from the criteria for the evaluation of the candidates for the position of the quality control manager given in Table 1, there is yet another one – *Salary*. In our case, the mentioned criterion is not involved in the given set because it is treated as a constant.

The first step in the application of the proposed framework involves the determination of the weights of the given criteria. Each *DM* makes his/her own estimation of the proposed criteria and, by using Eqs. (1)-(4), the final criteria weights are determined. The weights of the criteria for the first *DM* are presented in Table 2.

Criteria		s_j	k_j	q_j	w_j
C_1	Familiarity with the product and the materials used		1	1	0.19
C_2	Education and experience	1.00	1.00	1.00	0.19
C_3	Familiarity with administration	0.80	1.20	0.83	0.16
C_4	Flexibility	0.50	1.50	0.56	0.10
C_5	Risk assessment	1.30	0.70	0.79	0.15
C_6	Teamwork	1.30	0.70	1.13	0.21
				5.32	1.00

Table 2: Criteria weights – DM_1

The results presented in Table 2 show that the most significant criteria according to the DM_1 is the criteria C_6 – *Teamwork*. By applying the previously mentioned Eqs. (1)-(4), the criteria weights, which are in accordance with the standpoint of the DM_2, are determined (Table 3).

Criteria		s_j	k_j	q_j	w_j
C_1	Familiarity with the product and the materials used		1	1	0,15
C_2	Education and experience	1.10	0.90	1.11	0.16
C_3	Familiarity with administration	1.00	1.00	1.11	0.16
C_4	Flexibility	1.10	0.90	1.23	0.18
C_5	Risk assessment	1.00	1.00	1.23	0.18
C_6	Teamwork	0.90	1.10	1.12	0.16
				6.81	1.00

Table 3: Criteria weights – DM_2

As can be seen in Table 3, the most significant criteria in this case are the criteria C_4 – *Flexibility* and C_5 – *Risk assessment*. In Table 4, the weights of the criteria for the DM_3 obtained by applying Eqs. (1)-(4) are presented.

Criteria		s_j	k_j	q_j	w_j
C_1	Familiarity with the product and the materials used		1	1	0,16
C_2	Education and experience	1.20	0.80	1.25	0.20
C_3	Familiarity with administration	0.70	1.30	0.96	0.16
C_4	Flexibility	1.00	1.00	0.96	0.16
C_5	Risk assessment	1.00	1.00	0.96	0.16
C_6	Teamwork	1.10	0.90	1.07	0.17
				6.20	1.00

Table 4: Criteria weights – DM_3

According to the DM_3, the criterion C_2 – *Education and experience* stands out as the most significant.

In Tables 5, 6 and 7, the initial decision matrices are presented. Each matrix contains the estimations of the candidates relative to the six evaluation criteria. The assessment was performed by using the scale from 1 to 5, where 1 is the worst grade, and 5 is the best. Beside the given estimations and criteria weights, the decision matrices contain the *ppr* values for each *DM*.

		C_1	C_2	C_3	C_4	C_5	C_6
		max	max	max	min	max	max
	w_j	0.19	0.19	0.16	0.10	0.15	0.21
	ppr	*5*	*3*	*3*	*3*	*4*	*3*
Candidates	A_1	5	5	2	3	4	3
	A_2	4	3	5	3	3	3
	A_3	3	3	3	4	3	4
	A_4	1	3	2	4	2	2
	A_5	3	2	2	4	1	4
	A_6	2	2	4	3	1	4

Table 5: The initial decision matrix – DM_1

		C_1	C_2	C_3	C_4	C_5	C_6
		max	max	max	min	max	max
	w_j	0.15	0.16	0.16	0.18	0.18	0.16
	ppr	*3*	*4*	*2*	*3*	*3*	*2*
Candidates	A_1	4	4	4	2	3	3
	A_2	3	3	3	3	2	3
	A_3	2	4	3	4	2	4
	A_4	1	3	2	4	1	4
	A_5	2	2	2	4	2	3
	A_6	2	2	3	3	1	4

Table 6: The initial decision matrix – DM_2

		C_1	C_2	C_3	C_4	C_5	C_6
		max	max	max	min	max	max
	w_j	0.16	0.20	0.16	0.16	0.16	0.17
	ppr	*4*	*4*	*2*	*3*	*4*	*4*
Candidates	A_1	4	4	4	2	3	4
	A_2	3	3	4	3	4	5
	A_3	3	2	4	4	3	4
	A_4	2	2	3	4	2	5
	A_5	2	2	3	3	1	4
	A_6	2	3	3	3	2	3

Table 7: The initial decision matrix – DM_3

By applying Eqs. (6)-(12), the final results are defined and the rank of the considered alternatives, in this case the candidates, is determined. In Table 8, the final results for the DM_1 are presented in the case of the different values of γ.

	$\gamma = 0$		$\gamma = 0.5$			$\gamma = 1$		
	S_i'	*Rank*	c_i	S_i'	*Rank*	c_i	S_i'	*Rank*
A_1	0.0731	1	0.0627	0.0104	2	0.1254	-0.0522	2
A_2	0.0077	3	0.0392	-0.0315	3	0.0784	-0.0707	3
A_3	0.0673	2	0.0530	0.0143	1	0.1061	-0.0388	1

Table 8: The ranking of the candidates – DM_1

As the results show, the alternatives A_4, A_5 and A_6 are rejected during the procedure as unacceptable, and the first-ranked alternative according to the DM_1 is the alternative A_3, when $\gamma = 0.5$ and $\gamma = 1$. When primacy is given to the best alternative of all, i.e. when $\gamma = 0$, the alternative A_1 ranks the first.

	$\gamma = 0$		$\gamma = 0.5$			$\gamma = 1$		
	S_i'	*Rank*	c_i	S_i'	*Rank*	c_i	S_i'	*Rank*
A_1	0.2861	2	0.0726	0.2135	2	0.1451	0.1410	1
A_2	0.0741	3	0.0720	0.0022	3	0.1439	-0.0698	3
A_3	0.3620	1	0.1242	0.2379	1	0.2483	0.1137	2
A_4	0.0595	4	0.1349	-0.0754	4	0.2697	-0.2103	4
A_6	0.0178	5	0.1337	-0.1159	5	0.2675	-0.3147	5

Table 9: The ranking of the candidates – DM_2

The alternative A_3 is the best alternative according to the DM_2 when $ã = 0$ and $ã = 0.5$, but when $ã = 1$, the best-ranked is the alternative A_1. The alternative A_5 is excluded from the list of the suitable alternatives during the procedure (Table 9).

	$\gamma = 0$		$\gamma = 0.5$			$\gamma = 1$		
	S_i'	*Rank*	c_i	S_i'	*Rank*	c_i	S_i'	*Rank*
A_1	0.3677	2	0.1189	0.2488	2	0.2378	0.1299	1
A_2	0.4017	1	0.1378	0.2639	1	0.2756	0.1261	2
A_3	0.2406	3	0.1170	0.1236	3	0.2340	0.0067	3
A_4	0.0394	4	0.0768	-0.0373	4	0.1536	-0.1141	4

Table 10: The ranking of the candidates – DM_3

According to the DM_3, the most adequate alternative is the alternative A_2 when $\gamma = 0$ and $\gamma = 0.5$, whereas when $\gamma = 1$ and when a priority is given to the alternatives satisfying the previously set *ppr* values, the alternative A_1 is the best-ranked alternative.

With the aim of defining the overall ranking order of the considered alternatives based on the evaluation of all the three *DM*s, WA operators are used. The WA operators are applied by using the following Eq.:

$$S''_i = \frac{1}{n}\sum_{j=1}^{n} S'_i, \tag{13}$$

where S''_i stands for the overall performance rating of the alternatives according to all the *DM*s. The ranking is performed in ascending order and the optimal choice is the alternative whose S''_i is the highest.

	$\gamma = 0$		$\gamma = 0.5$		$\gamma = 1$	
	S''_i	*Rank*	S''_i	*Rank*	S''_i	*Rank*
A_1	0.2423	1	0.1576	1	0.0729	1
A_2	0.1612	3	0.0782	3	-0.0048	3
A_3	0.2233	2	0.1253	2	0.0272	2
A_4	0.0330	4	-0.0376	4	-0.1081	5
A_5	-	-	-	-	-	-
A_6	0.0059	5	-0.0386	5	-0.1049	4

Table 11: The overall ranking of the candidates

The alternative A_1 is singled out as the best choice (Table 11), which is completely justified because the candidate A_1 always took the first or second position in all of the three observations, which is especially suitable when primacy is given to the alternatives with a better matching with the pre-set *ppr* values.

4. CONCLUSION

The selection of an adequate candidate is a very complex task that requires the perception and evaluation of every aspect important for a concrete workplace. The significance of the selection of the optimal personnel for performing the function of the quality control manager is also great because a certain person's education, ability, knowledge and skills have quite an impact on producing products of an adequate quality. Because evaluation and personnel selection are conducted based on certain criteria which are very often conflicting, the application of the MCDM methods is absolutely justified and desirable.

In this case of ours, the proposed framework for the selection of the quality control manager is based on the PIPRECIA and WS PLP methods. The PIPRECIA method is used for the criteria weight determination, while the final evaluation and ranking are performed by using the WS PLP method. The applicability of the given framework is tested by an illustrative numerical example pointed to the evaluation of the six candidates relative to the six evaluation criteria. With the aim of reducing subjectivity and gaining a more reliable decision, group decision-making is applied, i.e. the evaluation is conducted by three *DM*s. Bearing in mind the fact that bias is present in the decision-making process, its effects are in this way minimized, which automatically increases the trustworthiness of the final choice.

The key advantages of this paper reflect in the proposal for the application of a suitable model that will facilitate the decision-making process and increase the validity of the final decision. The prerogative of the PIPRECIA method is its simplicity and convenience for utilization in a group decision-making environment. On the other hand, the main advantage of the WS PLP method reflects in a possibility of making a selection between the alternative that better fits the established requirements and the alternative that has the best performance ratings of all of them and exceeds the pre-set conditions. Despite the fact that all MCDM methods more or less incorporate *DM*s' preferences, they are exactly expressed through *ppr* values in the WS PLP methods.

The application of crisp numbers is the main deficiency of this paper because vagueness and uncertainty are not incorporated in a proper manner. Besides, in this case, no sensitivity analysis is performed in order to test the stability of the proposed framework and its resistance to changing conditions. At the same time, the given disadvantages could be treated as proposals for the improvement of the given framework. Irrespective of the foregoing deficiency, its applicability in the field of personnel selection, i.e. the selection of a quality control manager in this particular case, cannot be denied.

REFERENCES

[1] Zolfani, S. H., Rezaeiniya, N., Aghdaie, M. H., & Zavadskas, E. K. (2012) Quality control manager selection based on AHP-COPRAS-G methods: a case in Iran, *Economic research - Ekonomska istraživanja*, *25*(1), pp. 72-86.
[2] Churchman, C. W., Ackoff, R. L. (1954) An approximate measure of value, *Journal of the Operations Research Society of America*, *2*(2), pp. 172-187.
[3] Saaty, T. L. (1980) *The Analytic Hierarchy Process: planning, priority setting, resource allocation*, McGraw-Hill, New York.
[4] Hwang, C. L.; Yoon, K. (1981) *Multiple Attribute Decision Making - methods and application*, Springer, New York.
[5] Keršuliene, V., Zavadskas, E. K., Turskis, Z. (2010) Selection of rational dispute resolution method by applying new Step-wise Weight Assessment Ratio Analysis (SWARA), *Journal of Business Economics and Management*, *11*(2), pp. 243-258.
[6] Zavadskas, E. K., Turskis, J., Antucheviciene, A., Zakarevicius, A. (2012) Optimization of Weighted Aggregated Sum Product Assessment, *Elektronika ir elektrotechnika*, *122*(6), pp. 3-6.
[7] Keshavarz Ghorabaee, M., Zavadskas, E. K., Olfat, L., & Turskis, Z. (2015) Multi-criteria inventory classification using a new method of evaluation based on distance from average solution (EDAS), *Informatica*, *26*(3), pp. 435-451.
[8] Karabašević, D., Stanujkić, D., & Urošević, S. (2015) The MCDM Model for Personnel Selection Based on SWARA and ARAS Methods, *Management, 77*, pp. 43-53.
[9] Karabašević, D., Stanujkić, D., Urošević, S., & Maksimović, M. (2016) An approach to personnel selection based on Swara and Waspas methods, *Bizinfo (Blace) Journal of Economics, Management and Informatics*, *7*(1), pp. 1-11.
[10] Afshari, R. A., Nikolić, M., & Ćoćkalo, D. (2014) Applications of fuzzy decision making for personnel selection problem: A review, *Journal of Engineering Management and Competitiveness (JEMC)*, *4*(2), 68-77.

[11] Sadatrasool, M., Bozorgi-Amiri, A., & Yousefi-Babadi, A. (2016) Project manager selection based on project manager competency model: PCA–MCDM Approach, *Journal of Project Management*, *1*(1), pp. 7-20.

[12] Dodangeh, J., Sorooshian, S., & Afshari, A. R. (2014) Linguistic extension for group multicriteria project manager selection, *Journal of Applied Mathematics*, *2014*.

[13] Stanujkic, D., Zavadskas, E. K., Karabasevic, D., Smarandache, F., & Turskis, Z. (2017) The use of the PIvot Pairwise RElative Criteria Importance Assessment method for determining the weights of criteria, *Romanian Journal of Economic Forecasting*, *20*(4), pp. 116-133.

[14] Stanujkic, D., & Zavadskas, E. K. (2015) A modified weighted sum method based on the decision-maker's preferred levels of performances, *Studies in Informatics and Control, 24*(4), pp. 461-470.

[15] Shannon C. (1948) A Mathematical Theory of Communication, *Bell System Technical Journal*, *27*, pp. 379–423 and pp. 623–656.

[16] Krylovas, A., Zavadskas, E. K., Kosareva, N., & Dadelo, S. (2014) New KEMIRA method for determining criteria priority and weights in solving MCDM problem, *International Journal of Information Technology & Decision Making*, *13*(06), pp. 1119-1133.