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Improvement of business decision-making in the IT industry using the MCDM approach

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Abstract: *The selection of suitable individuals for critical roles within the organization can significantly affect the business efficiency and performance of the organization. For this reason, this article presents a multiple-criteria decision-making procedure for candidates' assessment in the Information Technologies industry (IT) using the integrated PIPRECIA-S and WS-PLP methods. The introduced approach involved defining the criteria' significance with the help of the PIPRECIA-S, while the WS-PLP method was used to evaluate candidates and harmonize the views of decision-makers attitudes. The applicability of the suggested technique was reviewed in the situation of selecting an IT Project Manager in an IT company. However, it can easily be adapted for similar cases of candidate selection.*

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***Keywords**: project managers, IT, business decision-making, MCDM,* PIPRECIA-S*, WS-PLP.*

Unapređenje poslovnog odlučivanja u IT industriji primenom VKO pristupa

***Apstrakt**: Izbor adekvatnih pojedinaca za obavljanje ključnih uloga u organizaciji značajno može uticati na poslovnu efikasnost i performanse organizacije. Zbog navedenog razloga u ovom radu je prikazana procedura višekriterijumskog odlučivanja za evaluaciju kandidata u industriji Informacionih tehnologija (IT) koja integriše primenu PIPRECIA-S i WS-PLP metoda. Predloženi pristup uključuje definisanje značaja kriterijuma uz pomoć PIPRECIA-S metode, dok je WS-PLP metoda upotrebljena za ocenu kandidata i usaglašavanje stavova donosilaca odluka. Primenljivost predložene tehnike proverena je na primeru selekcije IT projektnog menadžera u jednoj IT kompaniji, ali ista lako može biti prilagođena za primenu u sličnim slučajevima koji se odnose na izbor kandidata.*

***Ključne reči**: projektni menadžeri, IT, poslovno odlučivanje, VKO, PIPRECIA-S, WS-PLP.*

1. Introduction

Every day, people face different kinds of ordinary and business problems that are more or less complex. To find adequate and reliable solutions, the scientists introduced a new branch of management and statistics called Multiple-Criteria Decision-Making (MCDM). The MCDM became popular, especially in the 2000s, proposing various methods. These methods utilize different approaches that enable the selection of an optimal alternative from a given set regarding the chosen criteria.

The evaluation and selection of candidates are one of the areas in business where the MCDM methods are successfully applied. For example, Ozgormus et al. (2021) proposed a combination of the fuzzy DEMATEl, GRA, and QFD as a helpful approach for a successful decision process. Popovic (2021) used SWARA and CoCoSo methods for candidate selection, while Ersoy (2021) combined Entropy and CODAS methods for evaluating alternatives. Alguliyev et al. (2020) proposed candidate evaluation based on the modified fuzzy TOPSIS method combined with certain aggregation operators. Ulutas et al. (2020) introduced the grey PIPRECIA and OCRA methods as an aid to selecting optimal candidates in the IT industry. Karabasevic et al. (2018) proposed applying the EDAS method for the candidate selection within the same field. Bilgehan Erdem (2016) applied MCDM methods for evaluating employees in the IT industry.

Based on the opinions of various authors, different stages can be identified in the MCDM process. However, according to many authors, some phases are typical, such as identifying available alternatives or candidates, defining evaluation criteria and determining their significance, and evaluating alternatives or candidates.

The weighting coefficients could be determined using different MCDM techniques. The Analytic Hierarchy Process (AHP) method (Saaty, 1980) is undoubtedly the most famous. Nevertheless, until now, the scientists have proposed various new approaches, to mention some of them, RANking COMparison (RANCOM) (Więckowski et al., 2023), MEthod based on the Removal Effects of Criteria (MEREC) (Keshavarz-Ghorabaee et al., 2021), Full consistency (FUCOM) method (Pamucar et al., 2018), Criterion Impact LOSs (CILOS) (Zavadskas & Podvezko, 2016), Integrated Determination of Objective CRIteria Weights (IDOCRIW) (Zavadskas & Podvezko, 2016), and so on.

The MCDM methods based on different approaches pointed to finding adequate solutions and selecting the best alternative have also been introduced. Here, we will mention some of them such as: Axial-Distance-Based Aggregated Measurement (ADAM) (Krstić et al., 2023), Compromise Ranking of Alternatives from Distance to Ideal Solution (CRADIS) (Puška et al., 2022), COmprehensive Distance Based RAnking (COBRA) (Krstić et al., 2022), Measurement of alternatives and ranking according to COmpromise solution (MARCOS) (Stević et al., 2020), COmbined COmpromise SOlution (CoCoSo) (Yazdani et al., 2018), COmbinative Distance-based Assessment (CODAS) (Keshavarz Ghorabaee et al., 2016), MultiAttributive Ideal-Real Comparative Analysis (MAIRCA) (Pamučar et al., 2014), etc.

The Simplified PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA-S) method was created by Stanujkic et al. (2021) to give decision-makers (DMs) a simple procedure for defining the criteria weighting coefficients. PIPRECIA-S is a simplified variant of the plain PIPRECIA method introduced by Stanujkic et al. (2017a).

Stanujkic and Zavadskas (2015) introduced the modified Weighted Sum method based on the decision-maker's Preferred Levels of Performances (WS-PLP) method. This method was applied to facilitate decision-making in the following cases: manager selection in the field of quality management (Popović, 2019), construction project selection (Popovic et al., 2019a), location selection (Popovic et al., 2019b), hotel website quality evaluation (Karabasevic et al., 2019; Stanujkic et al., 2018), personal selection (Stanujkic et al., 2017b; Vujić et al., 2016), and so on.

The article considers an approach for candidates' assessment in the IT industry based on the PIPRECIA-S and WS-PLP methods. The reason for proposing this approach is to facilitate the assessment and better appreciate the decision-makers desires. More precisely, the MCDM methods usually emphasize the option that has the best performance of all considered. However, in some cases, decision-makers want to prioritize the alternative that better fits their requirements, which is not necessarily the best option. The WS PLP method is used for the assessment because it allows the decision-maker to compare the best with the option that better fulfills his/her requirements clearly outlined from the start. In that way, the decision-maker could decide whether he/she wants the best candidate or adequate candidate regarding particular performances. Therefore, the article involves the following sections: Section 2 presents the computing procedure of the PIPRECIA-S and WS-PLP methods. In Section 3, a proposed approach for optimal candidate selection is presented. Section 4 contains an empirical illustration of IT Project Manager evaluation and selection, followed by the conclusion.

2. Material and methods

2.1. The Simplified Pivot Pairwise Relative Criteria Importance Assessment method

The PIPRECIA-S was proposed to facilitate the determination of criteria weights. Unlike the PIPRECIA method, in the PIPRECIA-S, the importance of each criterion is compared with the importance of the first criterion. The main advantage of the PIPRECIA-S is its simplicity and ease of use in a group decision environment. Nevertheless, contrary to the Extended PIPRECIA method (PIPRECIA-E) (Stanujkic et al., 2017b) and the AHP method (Saaty, 1980), the PIPRECIA-S does not involve consistency checking, which is its crucial disadvantage.

The procedure for determining the criteria weights using the PIPRECIA-S method can be presented in the following way:

Step 1. Select the evaluation criteria.

Step 2. From the second criterion onward, assign relative importance of criteria s_j in the following way:

$$s_j = \begin{cases} > 1, & C_j \succ C_1 \\ 1, & C_j = C_1. \\ < 1, & C_j \prec C_1 \end{cases} \quad (1)$$

The values of s_j belong to the interval [0.1, 1.9], and the value of s_1 is always 1.

Step 3. From the second criterion onward, compute the value of coefficient k_j in the following way:

$$k_j = 2 - s_j. \quad (2)$$

The value of k_1 is always set to 1.

Step 4. From the second criterion onward, compute the recalculated weight q_j in the following way:

$$q_j = \frac{1}{k_j}. \quad (3)$$

The value of q_1 is always set to 1.

Step 5. Compute the relative weights w_j of the criteria as follows:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}. \quad (4)$$

2.2. The Weighted Sum with the Preferred Level of Performance method

The WS-PLP method was formed to enable decision-makers to set their preferred ratings for criteria and, based on that, evaluate the alternatives. The essential advantage of the WS PLP method is reflected in its ability to clearly distinguish the best option from the one that better fits under preferred conditions. This possibility and the procedure itself could be slightly confusing for the decision-makers who use it for the first time.

The WS-PLP method consists of two parts:

- In the first part, the overall performance ratings of alternatives S_i are calculated concerning the preferred ratings of criteria, and

- in the second part, the adjusted overall performance ratings of alternatives S_i' are calculated. The adjusted overall performance ratings allow DMs to achieve an appropriate balance between maximizing the value of S_i and better matching with DM's preferences (Stanujkic & Zavadskas, 2015).

2.2.1. The first part of the WS-PLP method

The mathematical procedure of the WS-PLP method for evaluating *m* alternatives based on *n* beneficial criteria can be described precisely as follows:

Step 1. Evaluate alternatives concerning the criteria and create a decision matrix *D* in the following way:

$$D = \left[x_{ij}\right]_{m \times n}, \tag{5}$$

where x_{ij} denotes the rating of the *i*-th alternative concerning *the j*-th criterion.

Step 2. Specify the preferred performance ratings for each criterion and form the virtual alternative in the following way:

$$A_0 = \{x_{01}, x_{02}, x_{03}, \dots, x_{0n}\}, \tag{6}$$

where x_{0j} denotes the preferred rating of the virtual alternative concerning the *j*-th criterion.

In some cases where DM has no preference for a criterion, the preferred rating is determined in the following way:

$$x_{0j} = max_i \; x_{ij}. \tag{7}$$

Step 3. Form a normalized decision matrix in the following way:

$$r_{ij} = \frac{x_{ij} - x_{0j}}{max_i \; x_{ij} - min_i \; x_{ij}}, \tag{8}$$

where r_{ij} denotes normalized rating *i*-th alternative concerning *j*-th criterion, and $r_{ij} \in (-1, 1)$. Depending on the relationship between x_{ij} and x_{0j}, r_{ij} can have the following values:

$$\begin{cases} r_{ij} > 0 & if \; x_{ij} > x_{0j} \\ r_{ij} = 0 & if \; x_{ij} = x_{0j}. \\ r_{ij} < 0 & if \; x_{ij} < x_{0j} \end{cases} \tag{9}$$

Step 4. Compute the overall performance ratings for alternatives in the following way:

$$S_i = \sum_{j=1}^{n} w_j \, r_{ij}. \tag{10}$$

Based on the first part of the WS-PLP method, the alternative with the greater value of S_i is more acceptable.

2.2.2. The second part of the WS-PLP method

As previously mentioned, the second part of the WS-PLP methods enables "fine-tuning" of the DMs preferences, or in other words, adjusting an appropriate ratio between higher values of S_i and better matching of the ratings of *i*–th alternative with the DMs preferences.

According to Stanujkic and Zavadskas (2015), the S_i' is calculated only for alternatives that fulfill the given condition $S_i > 0$ in the following way:

$$S_i' = S_i - \gamma c_i, \tag{11}$$

where c_i denotes the compensation coefficient, which should be calculated in the following way:

$$c_i = \lambda d_i^{max} + (1-\lambda)\bar{S}_i^+, \tag{12}$$

with:

$$d_i^{+max} = max_i(r_{ij}\, w_j), \tag{13}$$

$$\bar{S}_i^+ = \frac{S_i^+}{n_i^+}, \text{ and} \tag{14}$$

$$S_i^+ = \sum_{r_{ij}>0} r_{ij} w_j. \tag{15}$$

In Eq.(12), d_i^{+max} represents the maximum weighted normalized distance of the *i*–th alternative to the preferred weighted normalized performance ratings and $\bar{S}_i^+$ denotes the average performance ratings of *the i*–th alternative achieved based on all criteria whose normalized ratings are more significant than 0. In Eq. (14), n_i^+ denotes the number of criteria of *i*–th alternative whose normalized ratings are more significant than 0. Finally Eq. (11) and Eq. (12), γ and the λ are the coefficients, their values lie in the interval [0,1], and they are usually set to 0.5.

Just like the first part of the WS-PLP method, the alternative with the greater value of S_i' is demanded to be more acceptable.

3. A framework for evaluating candidates based on PIPRECIA-S and WS-PLP methods

In group multiple-criteria decision-making (GMCDM), it is essential to use the attitudes obtained from respondents in the best possible way to assess the alternatives. One of the usual ways of evaluating the alternative in a GMCDM environment is forming and using a group decision-making matrix based on the attitudes of all DMs included in the assessment. An alternative and much less frequently used approach presented in this article is based on calculations performed for each DM. In this way, each DM forms its ranking list of alternatives, and the final evaluation is made through negotiation or the theory of dominance.

The recommended approach that includes the PIPRECIA-S and WS-PLP methods can be divided into four phases that contain specified steps.

Phase I. Select a desired number of DMs who will execute the decision process and choose adequate alternatives (candidates) and assessment criteria.

Phase II. Define the weighting coefficients of the criteria. We used the PIPRECIA-S for that purpose, as shown in Section 2.

Phase III. Assess the alternative candidates using the WS-PLP approach, as Section 2 shows.

Alternative candidates were assessed against chosen criteria using the five-point Likert Scale, presented in Table 1.

Table 1. Criteria judgment scale

Degree	Explanation
5	Great
4	Acceptable
3	Moderate
2	Passable
1	Unsatisfactory

Source: Author's research

The proposed linguistic scale is optional, meaning that DMs can use any decimal number from the interval [1, 5] to express their preferences more precisely.

In this phase, the DMs express their standpoints regarding candidates' desired performances regarding the criteria that will be base for their future ranking.

Phase IV. Select the most appropriate candidate. As a result of conducted phase IV, we obtain the *K* ranking orders of the alternative candidates, where *K* represents the number of DMs involved in the evaluation. According to the theory of ordinal dominance, the alternative that occupies the first position most times is potentially the proper one. However, in some cases, when it is difficult to determine the dominant alternative, the evaluation process can be repeated and returned to phase II or phase III of the proposed framework.

4. A numerical illustration of the proposed approach

The usefulness of the introduced approach is presented using a numerical illustration of selecting an IT project manager in an IT company, which is considered in this section. The input data was collected from a real IT company whose name was not revealed because we needed permission. Five candidates for the position of IT Project Manager were evaluated based on the opinions of three Human Resources Managers (HRMs) using the following criteria:

- Education (*E*),
- Work background (*WB*),
- Diplomas and licenses (*DL*),
- Openness and team spirit (*OT*),
- Managing ability (*MA*),
- Ability to plan (*AP*), and
- Language knowledge (*LK*).

The criteria weights obtained from three HRMs (HR_1, HR_2, and HR_3) involved in the evaluation are presented in Tables 2 and 3. The procedure for defining the weighting coefficients based on the attitudes of the HR_1, using the PIPRECIA-S method, is summarized in Table 2, while the criteria weights gained from all of them are shown in Table 3.

Table 2. The weighting coefficients – HR_1The criteria weight obtained based on opinions of the first of the three HRMs

Criteria	s_j	k_j	q_j	w_j
E		1	1	0.11
WB	1.2	0.8	1.25	0.13
DL	1.2	0.8	1.25	0.13
OT	1.3	0.7	1.43	0.15
MA	1.3	0.7	1.43	0.15
AP	1.3	0.7	1.43	0.15
LK	1.35	0.65	1.54	0.16
			9.32	1.00

Source: Author's calculations

Table 3. The weighting coefficients - HR_1, HR_2, and HR_3

HRMs	HR_1	HR_2	HR_3
Criteria	w_j	w_j	w_j
E	0.11	0.11	0.11
WB	0.13	0.14	0.14
DL	0.13	0.14	0.11
OT	0.15	0.16	0.14
MA	0.15	0.16	0.16
AP	0.15	0.16	0.16
LK	0.16	0.15	0.16

Source: Author's calculations

The rating of the evaluated candidate concerning the chosen criteria, obtained from the involved HRMs, is shown in Tables 4, 5, and 6. The previously mentioned tables also show the favored ratings of performances for each criterion obtained from the three HRMs.

Table 4. The initial candidate assessment – HR_1

	E	*WB*	*DL*	*OT*	*MA*	*AP*	*LK*
*PM**	4	4	4	4	3	3	3
PM_1	4	3	3	3	4	3	4
PM_2	4	3	4	4	3	4	4
PM_3	5	5	4	3	3	4	3
PM_4	4	5	3	4	4	5	3
PM_5	5	4	3	3	4	4	3

Source: Author's calculations

Table 5. The initial candidate assessment – HR_2

	E	*WB*	*DL*	*OT*	*MA*	*AP*	*LK*
*PM**	3	3	3	3	3	4	4
PM_1	4	4	4	4	4	3	5
PM_2	4	4	3	4	4	4	4
PM_3	5	4	5	3	3	5	4
PM_4	4	5	3.4	5	3	5	3
PM_5	4	5	4	4	3	4	4

Source: Author's calculations

Table 6. The initial candidate assessment – HR_3

	E	*WB*	*DL*	*OT*	*MA*	*AP*	*LK*
*PM**	4	3	4	3	3	3	3
PM_1	4	4	4	4	4	3	5
PM_2	4	4	3	3	4	4	4
PM_3	5	5	4	3	4	5	4
PM_4	4	4	3	5	3	5	3
PM_5	4	5	4	4	3	4	4

Source: Author's calculations

The calculation details and the evaluation of candidates using the first and second parts of the WS-PLP method are summarized in Tables 7, 8, 9, and 10.

Table 7. The computation results – HR_1

	S_i	Ranks	d_i^{+max}	n_i^+	S_i^+	$\bar{S}_i^+$	S_i'	Final rank
PM_1	-0.04	5	0.16	2	0.32	0.16	-0.04	5
PM_2	0.17	2	0.16	2	0.24	0.12	0.16	2
PM_3	0.10	3	0.11	3	0.25	0.08	0.09	3
PM_4	0.24	1	0.15	3	0.37	0.12	0.23	1
PM_5	0.05	4	0.15	3	0.34	0.11	0.04	4

Source: Author's calculations

Table 8. The computation results – HR_2

	S_i	Ranks	d_i^{+max}	n_i^+	S_i^+	$\bar{S}_i^+$	S_i'	Final rank
PM_1	0.545	3	0.16	6	0.62	0.10	0.532	3
PM_2	0.482	5	0.16	4	0.48	0.12	0.473	5
PM_3	0.572	2	0.22	4	0.57	0.14	0.553	1
PM_4	0.573	1	0.27	5	0.65	0.13	0.537	2
PM_5	0.531	4	0.27	4	0.53	0.13	0.495	4

Source: Author's calculations

Table 9. The computation results – HR_3

	S_i	Ranks	d_i^{+max}	n_i^+	S_i^+	$\bar{S}_i^+$	S_i'	Final rank
PM_1	0.35	3	0.16	4	0.54	0.13	0.38	3
PM_2	0.80	1	0.16	4	0.47	0.12	0.82	1
PM_3	0.33	4	0.28	5	0.80	0.16	0.36	4
PM_4	0.52	2	0.16	3	0.45	0.15	0.53	2
PM_5	0.00	5	0.28	4	0.52	0.13	0.00	5

Source: Author's calculations

Table 10. the candidates ranking – HR_1, HR_2, and HR_3

	HR_1	HR_2	HR_3
PM_1	5	3	3
PM_2	2	5	1
PM_3	3	2	4
PM_4	1	1	2
PM_5	4	4	5

Source: Author's calculations

The specifics of calculations using the WS-PLP method can be seen in Table 7. Table 7 clearly outlines that the second part of the WS-PLP method can be applied only for methods for which the condition $S_i > 0$ is met according to the first part of the WS-PLP method. In this case, using the parameters $\lambda = 0.5$ and $\gamma = 0.5$, the second part of the WS-PLP method did not generate changes in the ranking positions of alternatives.

Also, essential characteristics of applying the WS-PLP method are presented in the case of evaluation based on the attitudes of HR_2. In this case, the use of decimal numbers for evaluating candidates concerning the criteria was demonstrated, as well as the application of the second part of the WSP-PLP method. From Table 8, it can be seen that between the candidates designated as PM_3 and PM_4 there is a significantly slight difference in the value of S_i, which is why the application of the second part of the WS-PLP method with the parameter values $\lambda = 0.5$ and $\gamma = 0.5$ affected the changes in the ranking order of the evaluated candidates.

The evaluation results presented in Table 10 show that the candidate denoted as PM_4 is the most suitable according to the attitudes of HR_1 and HR_2. In contrast, according to the attitudes of HRM_3, he is ranked second. Based on the Dominance Theory, the candidate marked as PM_4 is the most suitable candidate. However, due to differences in the attitudes of HR_3, the evaluation procedure can be repeated starting from phase II, i.e., the re-calculation of the criteria weight or the re-evaluation of the candidate in phase III. In addition, using the second part of the WS-PLP method, the standpoints of all HRMs included in the assessment process can be finalized.

The PIPRECIA-S enabled the successful determination of the criteria weights. However, because the results are based on the opinion of the decision-makers, they are subjectivized to some level. Additionally, the consistency testing of the gathered responses is not predicted, which is the shortcoming of this method. The WS PLP method helped evaluate the candidates involved in the procedure, but it could not express the decision-makers hesitation because the standpoints were expressed as crisp numbers. However, introducing adequate extensions will contribute to improving the proposed model.

5. Conclusion

The selection of adequate candidates for important positions in the organization can significantly affect its business efficiency and functioning, i.e., its competitiveness in a competitive environment. This is why many organizations attach increasing importance to the problem of selecting adequate candidates for critical positions.

By giving extensive theoretical background regarding the significance of the application of the MCDM methods within the field of candidate selection, the authors precisely outline their potential and ability to facilitate the decision process, making it more reliable. In addition to other approaches, evaluating candidates using MCDM methods, that is, applying GMCDM can be identified as one of the current approaches. Therefore, this article presents a framework for evaluating candidates in a group environment based on the application of the PIPRECIA-S and WS-PLP methods, where the PIPRECIA-S method is employed in determining the importance of criteria and the WS-PLP method is applied to evaluate alternatives. PIPRECIA-S was chosen to obtain the importance of criteria, that is, criteria weights, because it is based on a simple pairwise comparing procedure and has a simple calculation procedure that is easy to understand for decision-makers.

The WS-PLP method is chosen for the evaluation of alternatives because it allows DMs to include their opinions relative to the desired performances regarding the given criteria, it also has a simple and easy-to-understand calculation procedure, and it also has the possibility of adjusting between larger values of overall performance rating and better coinciding with DM expectations.

The proposed approach offers an easy procedure for assessing and selecting the candidates. As an alternative to PIPRECIA-S, the PIPRECIA-E could be used because it observes the consistency of the gathered information from decision-makers. Besides, the WISP method (Stanujkic et al., 2021) could be used as an additional method for candidate evaluation because its procedure is understandable and could contribute to facilitating the evaluation procedure.

The main benefit of the suggested approach relies on its ability to acknowledge the DM's preferences without interfering with the weight coefficients and ratings. In that way, the DMs could be aware of the best possible solution and the solution that better fulfills their preset requirements.

The essential limitation of the presented research is defining the weighting coefficients using only the subjective MCDM methods. In that way, the obtained results could be biased and reflect only the opinions of the decision-makers involved in the procedure. To avoid this kind of problem, it is recommended to involve the objective MCDM methods in the process of determining the criteria significance, such as MEREC (Keshavarz-Ghorabaee et al., 2021), KEMIRA (Krylovas et al., 2014) or similar. Besides, the number of decision-makers is modest; the results would be more relevant if more decision-makers were engaged. Introducing adequate extensions based on fuzzy or grey numbers would improve the proposed approach and make it more reliable and adequate for application in the uncertain decision environment. The mentioned limitations automatically represent the propositions for future research.

Finally, the introduced approach is valid and facilitates the decision process in human resource management.

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