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Human Resources Management Application Selection with fuzzy MAIRCA Method Based on fuzzy PIPRECIA [1]

Bulanık PIPRECIA Temelli Bulanık MAIRCA Yöntemi ile İnsan Kaynakları Yönetimi Uygulaması Seçimi

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Abstract

Today, the intense competitive environment for businesses creates complexity in the decision-making process. It is recommended to use Multi-Criteria Decision Making (MCDM) methods, which are one of the most effective and practical methods in solving complexities. In uncertain and indefinite situations, using Fuzzy MCDM methods instead of Classic MCDM methods provides an advantage in decision making. With fuzzy MCDM methods, subjective evaluations expressed verbally by decision makers are analyzed by integrating them with numerical values. In this study, the selection of human resources management application for a business operating in the fields of logistics, warehousing, sales and commercial marketing was made using the Fuzzy PIPRECIA and Fuzzy MAIRCA methods, which are among the Fuzzy MCDM methods. In the study, seven criteria and four alternatives were identified by taking the opinions of four decision makers. Among the seven criteria evaluated, the most important criterion was K7, which represents the technical support criterion, while the most suitable alternative among the four alternatives was determined as A1.

Keywords: *Fuzzy MCDM, Fuzzy PIPRECIA, Fuzzy MAIRCA, Choosing a Human Resources Management Application.*

Jel Codes: *C02, C44, C61.*

Öz

Günümüzde işletmeler için yoğun rekabet ortamının olması karar verme aşamasında karmaşıklık oluşturmaktadır. Karmaşıklıkların çözülmesinde en etkin ve pratik yöntemlerden olan Çok Kriterli Karar Verme (ÇKKV) yöntemlerinin kullanılması önerilmektedir. Belirsiz ve kesin olmayan durumlarda Klasik ÇKKV yöntemlerinin yerine Bulanık ÇKKV yöntemlerinin kullanılması karar vermede avantaj sağlamaktadır. Bulanık ÇKKV yöntemleri ile karar vericilerin sözel olarak ifade ettiği sübjektif değerlendirmeler sayısal değerlerle entegre edilerek çözümlenmektedir. Bu çalışmada, lojistik, depolama, satış ve ticari pazarlama alanında faaliyet sürdüren bir işletme için insan kaynakları yönetimi uygulaması seçimi Bulanık ÇKKV yöntemlerinden Bulanık PIPRECIA ve Bulanık MAIRCA yöntemleri kullanılarak yapılmıştır. Çalışmada dört karar vericinin görüşleri alınmış yedi kriter ve dört alternatif belirlenmiştir. Değerlendirilen yedi kriterden en önemli kriter teknik destek kriterini ifade eden K7 olurken dört alternatif arasından en uygun alternatif A1 olarak belirlenmiştir.

Anahtar Kelimeler: *Bulanık ÇKKV, Bulanık PIPRECIA, Bulanık MAIRCA, İnsan Kaynakları Yönetimi Uygulaması Seçimi.*

Jel Kodları: *C02, C44, C61.*

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1. INTRODUCTION

In order to ensure long-term sustainability in today's competitive environment, businesses require constant change and development (Erokutan, 2016: 1). Increasing sectoral performance by activating internal business activities provides a competitive advantage. Correct and effective decisions are made by businesses evaluating information in a timely manner (Karakaşoğlu, 2008: 1). Businesses can use Multi-Criteria Decision Making methods to make effective decisions in decision-making problems where there are many criteria and alternatives.

By ensuring the determination of numerous quantitative and qualitative criteria with Multi-Criteria Decision Making methods, criteria can be weighted and alternatives can be ranked (Yenilmezel and Ertuğrul, 2022: 252). As MCDM methods were insufficient in real life problems, Fuzzy MCDM methods were developed and more effective results were obtained (Yenilmezel Alıcı and Ertuğrul, 2023: 2).

In this study, the human resources application selection problem for a business operating in the field of logistics, warehousing, sales and commercial marketing is discussed. By choosing this application, which can be used on mobile and browser, the company can accelerate processes such as orientation training, debits, expenses, performance module, recruitment, survey, leave request and management, overtime tracking and e-signature, increase competitiveness in the digitalizing world and follow the sector has been made possible.

In solving the problem, the fuzzy PIPRECIA method was used to determine the weights of seven criteria evaluated by four people, namely the company's general manager, human resources officer, purchasing officer and information technology officer, while the ranking of the four alternatives was done by the fuzzy MAIRCA method. The fact that the methods used are new in the literature and are far from complexity provides an advantage over other methods.

2. LITERATURE REVIEW

When the literature is examined, there is no study on human resources management application selection. Additionally, no study has been found in which Fuzzy PIPRECIA and Fuzzy MAIRCA methods were used together. For this reason, separate literature research was conducted on the methods to be used in the study and they are presented below.

Table 1. Fuzzy PIPRECIA and Fuzzy MAIRCA Method Literature Review

Studies with Fuzzy PIPRECIA Method
Stanujkic et al. (2017) evaluation of SWOT elements for the implementation of barcode technology
Đalić et al. (2020) green supplier selection
Vesković et al. (2020) a study to choose the best solution for passenger rail operator's business balance
Marković et al. (2020) evaluation of bank performances
Stanković et al. (2020) road traffic risk analysis
Tomašević et al. (2020) evaluation of criteria for computing systems
Blagosević et al. (2020) safety assessment of railway traffic
Memiş et al. (2020) prioritization of road transport risks

Blagosević et al. (2021) evaluation of the degree of safety at railway crossings to achieve sustainable traffic management
Nedeljković et al. (2021) evaluation of rapeseed varieties
Taş (2021) determination of site selection criteria for medical waste
Özdağoğlu et al. (2021) truck tractor selection
Arman and Kundakcı (2022) evaluation of critical factors affecting the adoption of blockchain technology in the banking industry
Studies with Fuzzy MAIRCA Method
Boral et al. (2020) numerical implementation for risk assessment problems
Gül and Ak (2020) assessment of occupational risks in terms of human health and the environment
Ayadi et al. (2021) location selection for the logistics platform from a sustainable perspective

3. METHODS

Information about Fuzzy PIPRECIA and Fuzzy MAIRCA methods, which are used integrally in solving the human resources application selection problem for a business, is included.

3.1. Fuzzy PIPRECIA Method

Stanujkic et al. PIPRECIA (PIvot Pairwise RElative Criteria Importance Assessment) method developed by Kersuliene et al. It is an MCDM method that enables subjective evaluation of criterion weights as an extension of the SWARA method proposed by Stević et al. developed the Fuzzy PIPRECIA method, enabling decision makers to digitize their linguistic evaluations in real-life problems (Arman and Kundakcı, 2022: 86; Yenilmezel Alıcı and Ertuğrul, 2023: 4). Fuzzy PIPRECIA method process steps are given below (Stević et al., 2018: 7-9).

Step 1. Criteria are determined by the formed decision-making team. Criteria are listed regardless of their importance.

Step 2. Each decision maker evaluates the criteria listed starting from the second criterion with Equation (1) and determines the relative importance of the criteria.

$$\overline{s_j^r} = \begin{Bmatrix} > \bar{l}\ eğer\ C_j > C_{j-1} \\ = \bar{l}\ eğer\ C_j = C_{j-1} \\ < \bar{l}\ eğer\ C_j < C_{j-1} \end{Bmatrix} \tag{1}$$

$\overline{s_j^r}$, refers to the evaluation of the criteria by decision maker r. Using the arithmetic or geometric mean, the mean of the $\overline{s_j^r}$ matrix is found and the $\overline{s_j^r}$ matrix is obtained. Table 2 and Table 3 are used to evaluate the criteria. Table 2 is used when the criterion is more important than the previous criterion, while Table 3 is used when the criterion is less important than the previous criterion. In order to facilitate the evaluation of the decision makers, each comparison has been subjected to a process of clarification and is shown in Table 2 and Table 3.

l: lower bound value of triangular fuzzy number

m: triangular fuzzy number most promising value

u: triangular fuzzy number upper bound value

Table 2. The Linguistic Variables for The Evaluation of the Criteria (Scale 1-2)

Linguistic Variables	Fuzzy Number			
	l	m	u	Stabilized Value
Almost Equal Value	1,000	1,000	1,050	1,008
Slightly More Significant	1,100	1,150	1,200	1,150
Moderately More Significant	1,200	1,300	1,350	1,292
More Significant	1,300	1,450	1,500	1,433
Much More Significant	1,400	1,600	1,650	1,575
Dominantly More Significant	1,500	1,750	1,800	1,717
Absolutely More Significant	1,600	1,900	1,950	1,858

Table 3. The Linguistic Variables for the Evaluation of the Criteria (Scale 0-1)

Linguistic Variables	Fuzzy Number			
	l	m	u	Stabilized Value
Weakly Less Significant	0,667	1,000	1,000	0,944
Moderately Less Significant	0,500	0,667	1,000	0,694
Less Significant	0,400	0,500	0,667	0,511
Really Less Significant	0,333	0,400	0,500	0,406
Much Less Significant	0,286	0,333	0,400	0,337
Dominantly Less Significant	0,250	0,286	0,333	0,288
Absolutely Less Significant	0,222	0,250	0,286	0,251

Step 3. The coefficient $\overline{k_j}$ is determined by Equation (2).

$$\overline{k_j} = \begin{cases} \bar{l} \; if \; j = 1 \\ 2 - \overline{s_j} \; if \; j > 1 \end{cases} \tag{2}$$

Step 4. Equation (3) is used to find the fuzzy weight $\overline{q_j}$.

$$\overline{q_j} = \begin{cases} \bar{l} \; if \; j = 1 \\ \frac{\overline{q_{j-1}}}{\overline{k_j}} \; if \; j > 1 \end{cases} \tag{3}$$

Step 5. The relative weight of $\overline{w_j}$ is obtained with the help of Equation (4).

$$\overline{w_j} = \frac{\overline{q_j}}{\sum_{j=1}^{n} \overline{q_j}} \tag{4}$$

The following steps belong to the inverse fuzzy PIPRECIA method.

Step 6. Starting from the penultimate kiter, the criteria are evaluated according to Tables 2 and 3.

$$\overline{s_j^{r}}' = \begin{cases} > \bar{l} \; if \; C_j > C_{j+1} \\ = \bar{l} \; if \; C_j = C_{j+1} \\ < \bar{l} \; if \; C_j < C_{j+1} \end{cases} \tag{5}$$

$\overline{s_j^{r}}'$, denotes the evaluation of the criteria by decision maker r.

Step 7. Equation (6) shows the coefficient $\overline{k_j'}$.

$$\overline{k_j}' = \begin{cases} \bar{l} \; if \; j = n \\ 2 - \overline{s_j}' if \; j > n \end{cases} \tag{6}$$

n is the total number of criteria.

Step 8. The fuzzy weight $\bar{q_J}'$ is obtained by Equation (7).

$$\bar{q_J}' = \begin{cases} \bar{l}\ if\ j = n \\ \frac{q_{J+1}'}{k_J'}\ if\ j > n \end{cases} \tag{7}$$

Step 9. The relative weight of criterion $\overline{w_J}'$ is calculated by Equation (8).

$$\overline{w_J}' = \frac{\overline{q_J}'}{\sum_{j=1}^{n} \overline{q_J}'} \tag{8}$$

Step 10. $\overline{w_J}$ and $\overline{w_J}'$ values obtained for determining the final weights of the criteria are analyzed with Equation (9).

$$\overline{w_J}'' = \frac{1}{2}(\overline{w_J} + \overline{w_J}') \tag{9}$$

3.2. Fuzzy MAIRCA Method

Pamucar et al. (2014) developed by MAIRCA (MultiAttributive Ideal-Real Comparative Analysis) method is basically based on determining the difference between ideal and experimental weights and calculating the sum of the gaps for each criterion and the total gap for each evaluated alternative. After the calculations, the best alternative is the one with the lowest gap value (Gigović et al., 2016: 11). One of the advantages of the method is that it has an easy and understandable mathematical algorithm. The Fuzzy MAIRCA method was introduced to the literature by using the method with linguistic expressions (Boral et al. 2020, 11). The linguistic scale used is given in Table 4.

Table 4. Fuzzy MAIRCA Method Linguistic Scale

Linguistic Variables	Fuzzy Number		
	l	m	u
Very Weak (VP)	0	0	1
Weak (P)	0	1	3
Average Weak (MP)	1	3	5
Equal (F)	3	5	7
Average Good (MG)	5	7	9
Good G)	7	9	10
Very Good (VG)	9	10	10

The fuzzy MAIRCA method consists of 9 steps and the process steps are as follows (Boral et al., 2020: 11-13).

Step 1. As a result of evaluating m alternatives according to n criteria and evaluating the alternatives with linguistic expressions in the context of the criteria considered, the initial linguistic evaluation matrix (DL) is created as follows.

$$D_L = \begin{pmatrix} L_{11}^1, & \cdots L_{11}^k & L_{12}^1, & \cdots L_{12}^k \cdots & L_{1n}^1, & \cdots L_{1n}^k \\ L_{11}^1, & \cdots L_{11}^k & L_{22}^1, & \cdots L_{22}^k \cdots & L_{2n}^1, & \cdots L_{2n}^k \\ & \vdots & & \ddots & & \vdots \\ & \vdots & & \ddots & & \vdots \\ L_{m1}^1, & \ldots L_{m1}^k & L_{m2}^1, & \ldots L_{m2}^k \ldots & L_{mn}^1, & \ldots L_{mn}^k \end{pmatrix} \tag{10}$$

L_{mn}^{k}, shows that m alternatives are linguistically evaluated by k decision makers under n criteria.

Step 2. Following the ranking of alternatives through fuzzy numbers, each linguistic decision is replaced by fuzzy numbers as in Equation (11).

$$\widetilde{D}^1 = \begin{pmatrix} \tilde{A}_{11}^{(1)} & \tilde{A}_{12}^{(1)} & \cdots & \tilde{A}_{1n}^{(1)} \\ \tilde{A}_{21}^{(1)} & \tilde{A}_{22}^{(1)} & \cdots & \tilde{A}_{2n}^{(1)} \\ \vdots & & \ddots & \vdots \\ \tilde{A}_{m1}^{(1)} & \tilde{A}_{m2}^{(1)} & \cdots & \tilde{A}_{mn}^{(1)} \end{pmatrix}, \cdots, \widetilde{D}^k = \begin{pmatrix} \tilde{A}_{11}^{(k)} & \tilde{A}_{12}^{(k)} & \cdots & \tilde{A}_{1n}^{(k)} \\ \tilde{A}_{21}^{(k)} & \tilde{A}_{22}^{(k)} & \cdots & \tilde{A}_{2n}^{(k)} \\ \vdots & & \ddots & \vdots \\ \tilde{A}_{m1}^{(k)} & \tilde{A}_{m2}^{(k)} & \cdots & \tilde{A}_{mn}^{(k)} \end{pmatrix} \quad (11)$$

Step 3. In this step, the integrated decision matrix is created with Equation (12).

$$\widetilde{D} = \begin{pmatrix} \tilde{A}_{11} & \tilde{A}_{12} & \cdots & \tilde{A}_{1n} \\ \tilde{A}_{21} & \tilde{A}_{22} & \cdots & \tilde{A}_{22} \\ \vdots & & \ddots & \vdots \\ \tilde{A}_{m1} & \tilde{A}_{m2} & \cdots & \tilde{A}_{mn} \end{pmatrix} \quad (12)$$

Thus, it is calculated as $\tilde{A}_{11} = \frac{\tilde{A}_{11}^{(1)} + \tilde{A}_{11}^{(2)} + \cdots + \tilde{A}_{11}^{(k)}}{k}$.

Step 4. In this step P_{A_i}preferences are defined according to the choice of alternatives and it means that the decision maker is neutral about the choice of an alternative. Since any alternative can be chosen with equal probability, the preferences for each of the alternatives are represented by Equation (13).

$$P_{A_i} = \frac{1}{m} \; ; \; \sum_{i=1}^{m} P_{A_i} = 1 \quad (13)$$

Step 5. The fuzzy theoretical evaluation matrix $\tilde{T}_{P_A}$), is calculated by multiplying the weights defined by the preferences made according to the alternatives, P_{A_i} as seen in Equation (14).

$$(\tilde{T}_{P_A}) = \begin{pmatrix} \frac{1}{m}\,\widetilde{w}\,1 & \frac{1}{m}\,\widetilde{w}\,2 & \cdots & \frac{1}{m}\,\widetilde{w}\,n \\ \frac{1}{m}\,\widetilde{w}\,1 & \frac{1}{m}\,\widetilde{w}\,2 & \cdots & \frac{1}{m}\,\widetilde{w}\,n \\ \vdots & & \ddots & \vdots \\ \frac{1}{m}\,\widetilde{w}\,1 & \frac{1}{m}\,\widetilde{w}\,2 & \cdots & \frac{1}{m}\,\widetilde{w}\,n \end{pmatrix} = \begin{pmatrix} \tilde{t}_{p11} & \tilde{t}_{p12} & \cdots & \tilde{t}_{pn1} \\ \tilde{t}_{p21} & \tilde{t}_{p22} & \cdots & \tilde{t}_{pn2} \\ \vdots & & \ddots & \vdots \\ \tilde{t}_{pm1} & \tilde{t}_{pm2} & \cdots & \tilde{t}_{pmn} \end{pmatrix} \quad (14)$$

Step 6. In order to reduce the complexity in the calculations and increase the accuracy of the numerical representation, the normalization process is performed as shown in Equation (15).

$$n_{ij}^{l} = \frac{a_{ij}^{l}}{\sqrt{\sum_{i=1}^{m}\left[(a_{ij}^{l})^2 + (a_{ij}^{m})^2 + (a_{ij}^{u})^2\right]}}$$

$$n_{ij}^{m} = \frac{a_{ij}^{m}}{\sqrt{\sum_{i=1}^{m}\left[(a_{ij}^{l})^2 + (a_{ij}^{m})^2 + (a_{ij}^{u})^2\right]}} \quad (15)$$

$$n_{ij}^{u} = \frac{a_{ij}^{u}}{\sqrt{\sum_{i=1}^{m}\left[(a_{ij}^{l})^2 + (a_{ij}^{m})^2 + (a_{ij}^{u})^2\right]}}$$

Step 7. The fuzzy elements of the theoretical calculation matrix ($\tilde{T}_{r_A}$) are calculated. In this step, the normalized decision matrix elements are multiplied by the theoretical calculation matrix elements, as given in Equation (16).

$$(\tilde{T}_{r_A}) = \begin{pmatrix} \tilde{t}_{r11} & \tilde{t}_{r12} & \cdots & \tilde{t}_{rn1} \\ \tilde{t}_{r21} & \tilde{t}_{r22} & \cdots & \tilde{t}_{rn2} \\ \vdots & & \ddots & \vdots \\ \tilde{t}_{rm1} & \tilde{t}_{rm2} & \cdots & \tilde{t}_{rmn} \end{pmatrix} = \begin{pmatrix} \tilde{n}_{11} \otimes \tilde{t}_{p11} & \tilde{n}_{11} \otimes \tilde{t}_{p12} & \cdots & \tilde{n}_{11} \otimes \tilde{t}_{pn1} \\ \tilde{n}_{21} \otimes \tilde{t}_{p21} & \tilde{n}_{22} \otimes \tilde{t}_{p22} & \cdots & \tilde{n}_{n2} \otimes \tilde{t}_{pn2} \\ \vdots & & \ddots & \vdots \\ \tilde{n}_{m1} \otimes \tilde{t}_{pm1} & \tilde{n}_{m2} \otimes \tilde{t}_{p22} & \cdots & \tilde{n}_{nm} \otimes \tilde{t}_{pn2} \end{pmatrix} \tag{16}$$

Step 8. In this step, the gap between the theoretical and actual evaluation of each alternative according to each criterion is calculated. The total void matrix is found as follows using Equation (17).

$$g_{ij} = \sqrt{\frac{1}{3}\left[(\tilde{t}_{pij_l} - \tilde{t}_{rij_l})^2 + (\tilde{t}_{pij_m} - \tilde{t}_{rij_m})^2 + (\tilde{t}_{pij_u} - \tilde{t}_{rij_u})^2\right]} \tag{17}$$

Step 9. In the last step, the final value of the criterion functions is calculated by summing the gap values of each alternative according to each criterion using Equation (18). The found values are arranged from largest to smallest and the preferences are ranked. The alternative with the lowest gap value is the best alternative.

$$Q_i = \sum_{j=1}^{n} g_{ij}, i = 1, 2, \dots, m. \tag{18}$$

4. APPLICATION

Fuzzy PIPRECIA method was used to determine the weights of seven criteria created by the evaluation of four decision makers, namely HR, Purchasing, IT and General Manager, for the selection of human resources application for a business that is the subject of the study, and the evaluation of the four alternatives determined was made with the Fuzzy MAIRCA method.

Table 5 shows the criteria to be used in the study.

Table 5. Criteria, Objectives and Codes to be used in the Study

Criteria	Objectives	Codes
Price	Minimum	K1
Language	Maximum	K2
Memory Usage	Minimum	K3
Performance	Maximum	K4
Flexibity	Maximum	K5
Ease of Use	Maximum	K6
Technical Support	Maximum	K7

4.1. Determination of Weights with the Fuzzy PIPRECIA Method

Seven criteria were determined by consulting four decision makers in the business: HR officer, IT, Purchasing officer and General Manager. Fuzzy PIPRECIA method was used to determine the weights of the criteria. Decision makers' evaluations and the process steps of the Fuzzy PIPRECIA method are given below.

As a first step, the results were obtained by applying Equation (1) with the help of Tables 2 and 3 for the normal Fuzzy PIPRECIA evaluations of decision makers and are given integrally in Table 6.

Table 6. Evaluations of Four Decision Makers on Seven Criteria for the Normal Fuzzy PIPRECIA Method

	KV1			KV2			KV3			KV4		
K1												
K2	0,222	0,250	0,286	0,250	0,286	0,333	0,250	0,286	0,333	0,222	0,250	0,286
K3	1,600	1,900	1,858	1,500	1,750	1,800	1,500	1,750	1,800	1,300	1,450	1,500
K4	1,300	1,450	1,500	1,300	1,450	1,500	1,300	1,450	1,500	1,300	1,450	0,150
K5	1,400	1,600	1,650	0,500	0,667	1,000	1,100	1,150	1,200	1,200	1,300	1,350
K6	0,400	0,500	0,667	1,100	1,150	1,200	1,000	1,000	1,050	0,400	0,500	0,667
K7	1,200	1,300	1,350	1,400	1,600	1,650	1,300	1,450	1,500	1,100	1,150	1,200

The $\overline{k_j}$coefficient is determined with Equation (2), the fuzzy weight of $\overline{q_j}$ with Equation (3), and the relative weight of $\overline{w_j}$ with the help of Equation (4) and is given in Table 7.

Table 7. Normal Fuzzy Results of PIPRECIA Application

	$\overline{s_j}$			$\overline{k_j}$			$\overline{q_j}$			$\overline{w_j}$		
K1				1,000	1,000	1,000	1,000	1,000	1,000	0,068	0,052	0,121
K2	0,236	0,267	0,309	1,691	1,733	1,764	0,567	0,577	0,591	0,038	0,030	0,072
K3	1,471	1,704	1,733	0,267	0,296	0,529	1,071	1,952	2,218	0,073	0,101	0,269
K4	1,300	1,450	0,844	1,156	0,550	0,700	1,530	3,549	1,918	0,104	0,183	0,233
K5	0,980	1,124	1,279	0,721	0,876	1,020	1,501	4,051	2,659	0,102	0,209	0,322
K6	0,648	0,732	0,865	1,135	1,268	1,352	1,110	3,195	2,343	0,075	0,165	0,284
K7	1,245	1,365	1,415	0,585	0,635	0,755	1,470	5,029	4,006	0,100	0,260	0,486

In the continuation of the method, inverse fuzzy PIPRECIA process steps were applied. As a first step, the criteria were evaluated by decision makers using Equation (5) and Tables 2 and 3, and are shown integratedly in Table 8.

Table 8. Evaluations of Four Decision Makers on Seven Criteria for the Inverse Fuzzy PIPRECIA Method

	KV1			KV2			KV3			KV4		
K1												
K2	0,400	0,500	0,667	0,400	0,500	0,667	0,400	0,500	0,667	0,286	0,333	0,400
K3	1,400	1,600	1,650	0,286	0,333	0,400	0,500	0,667	1,000	1,300	1,450	1,500

K_4	0,667	1,000	1,000	1,200	1,300	1,350	0,500	0,667	1,000	0,500	0,667	1,000
K_5	0,286	0,333	0,400	0,400	0,500	0,667	0,400	0,500	0,667	0,400	0,500	0,667
K_6	0,250	0,286	0,333	0,250	0,286	0,333	0,250	0,286	0,333	0,286	0,333	0,400
K_7	1,600	1,900	1,950	1,500	1,750	1,800	1,500	1,750	1,800	1,600	1,900	1,950

In the next step, by obtaining the coefficient $\bar{k}_j{}'$ with Equation (6), fuzzy weight values with $\bar{q}_j{}'$ with Equation (7), and relative weight values with $\bar{w}_j{}'$ with Equation (8), Table 9 is shown. The results are shown in Table 9.

Table 9. Results of Inverse Fuzzy PIPRECIA Application

	$\bar{s}_j{}'$			$\bar{k}_j{}'$			$\bar{q}_j{}'$			$\bar{w}_j{}'$		
K_1				1,000	1,000	1,000	1,000	1,000	1,000	0,151	0,234	0,326
K_2	0,368	0,452	0,587	1,413	1,548	1,632	0,613	0,646	0,708	0,092	0,151	0,230
K_3	0,714	0,847	0,997	1,003	1,153	1,286	0,477	0,560	0,706	0,072	0,131	0,230
K_4	0,669	0,872	1,078	0,922	1,128	1,331	0,358	0,497	0,766	0,054	0,116	0,249
K_5	0,368	0,452	0,587	1,413	1,548	1,632	0,219	0,321	0,542	0,033	0,075	0,176
K_6	0,259	0,297	0,349	1,651	1,703	1,741	0,126	0,188	0,328	0,019	0,044	0,107
K_7	1,549	1,823	1,873	0,127	0,177	0,451	0,279	1,067	2,594	0,042	0,249	0,844

As the last step, the arithmetic mean of the values was calculated using Equation (9) to obtain the final weights of the criteria. The obtained values are shown in Table 10.

Table 10. Subjective Weights of Criteria

	$\bar{w}_j{}''$			
	l	**m**	**u**	**DF**
K_1	0,0550	0,1505	0,4828	0,1900
K_2	0,0287	0,0369	0,0892	0,0443
K_3	0,0528	0,0879	0,2227	0,1045
K_4	0,0789	0,1497	0,2409	0,1531
K_5	0,0868	0,1701	0,2761	0,1739
K_6	0,0838	0,1580	0,2573	0,1622
K_7	0,1251	0,2468	0,4056	0,2530

4.2. Ranking of Alternatives with Fuzzy MAIRCA Method

After determining the criterion weights, the alternatives were evaluated with the Fuzzy MAIRCA method. The evaluation steps are given below.

Table 11. Integrated Evaluation Results of Alternatives According to the Fuzzy MAIRCA Method

	K1			K2			K3			K4			K5			K6			K7		
	l	**m**	**u**	**L**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
	0,0550	**0,1505**	**0,4828**	**0,0287**	**0,0369**	**0,0892**	**0,0528**	**0,0879**	**0,2227**	**0,0789**	**0,1497**	**0,2409**	**0,0868**	**0,1701**	**0,2761**	**0,0838**	**0,1580**	**0,2573**	**0,1251**	**0,2468**	**0,4056**
A1	8,50	9,75	10,00	4,00	6,00	8,00	9,00	10,00	10,00	9,00	10,00	10,00	6,50	8,50	9,75	8,00	9,50	10,00	9,00	10,00	10,00
A2	7,50	9,00	9,75	4,00	6,00	8,00	6,50	8,50	9,75	6,50	8,50	9,75	2,50	4,50	6,50	8,50	9,75	10,00	0,25	1,25	3,00
A3	0,00	0,00	1,00	4,00	6,00	8,00	0,25	1,50	3,50	8,50	9,75	10,00	4,50	6,50	8,50	7,00	9,00	10,00	1,25	3,00	5,00
A4	0,75	2,50	4,50	4,00	6,00	8,00	2,00	4,00	6,00	4,50	6,50	8,50	6,50	8,50	9,75	5,00	7,00	9,00	3,00	5,00	7,00

In the rest of the method, preferences are defined according to the selection of P_{A_i} alternatives with Equation (13) and it shows that any alternative can be chosen with equal probability. After finding this value, Equation (14) was used to obtain the theoretical evaluation matrix. The results are given in Table 12.

Table 12. Theoretical Evaluation Matrix

	K1			K2			K3			K4			K5			K6			K7		
	l	**m**	**u**	**L**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
	0,0550	**0,1505**	**0,4828**	**0,0287**	**0,0369**	**0,0892**	**0,0528**	**0,0879**	**0,2227**	**0,0789**	**0,1497**	**0,2409**	**0,0868**	**0,1701**	**0,2761**	**0,0838**	**0,1580**	**0,2573**	**0,1251**	**0,2468**	**0,4056**
A1	0,0138	0,0376	0,1207	0,0072	0,0092	0,0223	0,0132	0,0220	0,0557	0,0197	0,0374	0,0602	0,0217	0,0425	0,0690	0,0210	0,0395	0,0643	0,0313	0,0617	0,1014
A2	0,0138	0,0376	0,1207	0,0072	0,0092	0,0223	0,0132	0,0220	0,0557	0,0197	0,0374	0,0602	0,0217	0,0425	0,0690	0,0210	0,0395	0,0643	0,0313	0,0617	0,1014
A3	0,0138	0,0376	0,1207	0,0072	0,0092	0,0223	0,0132	0,0220	0,0557	0,0197	0,0374	0,0602	0,0217	0,0425	0,0690	0,0210	0,0395	0,0643	0,0313	0,0617	0,1014
A4	0,0138	0,0376	0,1207	0,0072	0,0092	0,0223	0,0132	0,0220	0,0557	0,0197	0,0374	0,0602	0,0217	0,0425	0,0690	0,0210	0,0395	0,0643	0,0313	0,0617	0,1014

The values were normalized using Equation (15) and are given in Table 13.

Table 13. Normalization Matrix

	K1			K2			K3			K4			K5			K6			K7		
	l	**m**	**u**	**L**	**M**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
	0,0550	**0,1505**	**0,4828**	**0,0287**	**0,0369**	**0,0892**	**0,0528**	**0,0879**	**0,2227**	**0,0789**	**0,1497**	**0,2409**	**0,0868**	**0,1701**	**0,2761**	**0,0838**	**0,1580**	**0,2573**	**0,1251**	**0,2468**	**0,4056**
A1	0,7482	0,7221	0,6799	0,5000	0,5000	0,5000	0,7976	0,7245	0,6411	0,6127	0,5684	0,5218	0,6170	0,5908	0,5586	0,5517	0,5350	0,5123	0,9402	0,8589	0,7392
A2	0,6602	0,6666	0,6629	0,5000	0,5000	0,5000	0,5761	0,6158	0,6251	0,4425	0,4831	0,5087	0,2373	0,3128	0,3724	0,5862	0,5491	0,5123	0,0261	0,1074	0,2218

A_3	0,0000	0,0000	0,0680	0,5000	0,5000	0,5000	0,0222	0,1087	0,2244	0,5787	0,5542	0,5218	0,4271	0,4518	0,4870	0,4828	0,5068	0,5123	0,1306	0,2577	0,3696
A_4	0,0660	0,1852	0,3060	0,5000	0,5000	0,5000	0,1773	0,2898	0,3847	0,3064	0,3694	0,4435	0,6170	0,5908	0,5586	0,3448	0,3942	0,4611	0,3134	0,4294	0,5175

Equation (16) was used to obtain the real thinking matrix. The results obtained are given in Table 14.

Table 14. Real Thinking Matrix

	K_1			**K_2**			**K_3**			**K_4**			**K_5**			**K_6**			**K_7**		
	l	**m**	**u**	**L**	**M**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
	0,0550	**0,1505**	**0,4828**	**0,0287**	**0,0369**	**0,0892**	**0,0528**	**0,0879**	**0,2227**	**0,0789**	**0,1497**	**0,2409**	**0,0868**	**0,1701**	**0,2761**	**0,0838**	**0,1580**	**0,2573**	**0,1251**	**0,2468**	**0,4056**
A_1	0,0103	0,0272	0,0821	0,0036	0,0046	0,0112	0,0105	0,0159	0,0357	0,0121	0,0213	0,0314	0,0134	0,0251	0,0386	0,0116	0,0211	0,0330	0,0294	0,0530	0,0750
A_2	0,0091	0,0251	0,0800	0,0036	0,0046	0,0112	0,0076	0,0135	0,0348	0,0087	0,0181	0,0306	0,0051	0,0133	0,0257	0,0123	0,0217	0,0330	0,0008	0,0066	0,0225
A_3	0,0000	0,0000	0,0082	0,0036	0,0046	0,0112	0,0003	0,0024	0,0125	0,0114	0,0207	0,0314	0,0093	0,0192	0,0336	0,0101	0,0200	0,0330	0,0041	0,0159	0,0375
A_4	0,0009	0,0070	0,0369	0,0036	0,0046	0,0112	0,0023	0,0064	0,0214	0,0060	0,0138	0,0267	0,0134	0,0251	0,0386	0,0072	0,0156	0,0297	0,0098	0,0265	0,0525

Equation (17) was used to calculate the gap value between the theoretical and actual evaluation of each alternative according to each criterion. The gap matrix is shown in Table 15.

Table 15. Void Matrix

	K_1			**K_2**			**K_3**			**K_4**			**K_5**			**K_6**			**K_7**		
	l	**m**	**u**	**L**	**M**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**
	0,0550	**0,1505**	**0,4828**	**0,0287**	**0,0369**	**0,0892**	**0,0528**	**0,0879**	**0,2227**	**0,0789**	**0,1497**	**0,2409**	**0,0868**	**0,1701**	**0,2761**	**0,0838**	**0,1580**	**0,2573**	**0,1251**	**0,2468**	**0,4056**
A_1	0,0035	0,0105	0,0386	0,0036	0,0046	0,0112	0,0027	0,0061	0,0200	0,0076	0,0162	0,0288	0,0083	0,0174	0,0305	0,0094	0,0184	0,0314	0,0019	0,0087	0,0264
A_2	0,0047	0,0125	0,0407	0,0036	0,0046	0,0112	0,0056	0,0084	0,0209	0,0110	0,0193	0,0296	0,0166	0,0292	0,0433	0,0087	0,0178	0,0314	0,0305	0,0551	0,0789
A_3	0,0138	0,0376	0,1125	0,0036	0,0046	0,0112	0,0129	0,0196	0,0432	0,0083	0,0167	0,0288	0,0124	0,0233	0,0354	0,0108	0,0195	0,0314	0,0272	0,0458	0,0639
A_4	0,0128	0,0307	0,0838	0,0036	0,0046	0,0112	0,0109	0,0156	0,0343	0,0137	0,0236	0,0335	0,0083	0,0174	0,0305	0,0137	0,0239	0,0347	0,0215	0,0352	0,0489

In the last step of the method, the gap values of each alternative were collected according to each criterion and listed from largest to smallest, using Equation (18). The alternative with the lowest gap value was the best alternative. When we look at the final results, the best alternative was the A_1 alternative.

Table 16. Evaluation

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	Final Value of the Criterion Functions	Arrangement
A_1	0,0140	0,0055	0,0078	0,0168	0,0181	0,0190	0,0105	0,0918	1
A_2	0,0159	0,0055	0,0100	0,0197	0,0295	0,0185	0,0549	0,1541	2
A_3	0,0461	0,0055	0,0224	0,0173	0,0235	0,0200	0,0457	0,1806	4
A_4	0,0365	0,0055	0,0179	0,0236	0,0181	0,0240	0,0352	0,1609	3

5. CONCLUSION

Businesses have to make strategic decisions in order to ensure their continuity as the competitive environment increases. This decision making is not always simple and can involve complexity. The use of mathematical methods provides more effective results in eliminating this complexity. One of these methods is Multi-Criteria Decision Making methods.

Multi-Criteria Decision Making methods enable realistic solutions to be achieved by analyzing multiple criteria and alternatives with quantitative and qualitative data. Fuzzy MCDM methods have emerged as MCDM methods are inadequate in solving real life problems. With fuzzy MCDM methods, verbal evaluations made by decision makers are analyzed by integrating them with numerical values.

In this study, the selection of human resources management application for a business operating in the field of logistics, warehousing, sales and commercial marketing is discussed. By choosing this application, the business will be able to quickly and easily track its transactions in many areas.

In order to determine the criterion weights in solving the problem, seven criteria, namely price, language, memory usage, performance, flexibility, ease of use and technical support, were determined by evaluating four decision makers among the company employees, consisting of the general manager, human resources officer, information technology officer and purchasing officer, and their weights were obtained. Fuzzy PIPRECIA method was used in the analysis. According to the results of the fuzzy PIPRECIA method, the criterion with the highest value was the K_7 criterion, which represents the technical support criterion, and the order of the criteria was determined as $K_7 > K_1 > K_5 > K_6 > K_4 > K_3 > K_2$.

According to the fuzzy MAIRCA method used to determine the four alternatives, the best alternative was A1, and the ranking of the alternatives was A1 > A2 > A4 > A3.

In the light of the results obtained, the results obtained using different fuzzy MCDM methods can be compared in the selection of human resources applications for future studies. Additionally, new results can be obtained by adding different criteria and alternatives. In addition, these methods can be used in different supplier selection, machine selection, personnel selection or a project selection and the results can be evaluated.

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