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THE APPLICATION OF SWARA BASED COPRAS AND OCRA METHODS TO SUPPLIER SELECTION PROBLEM [τ]

TEDARİKÇİ SEÇİMİNDE SWARA TABANLI COPRAS VE OCRA YÖNTEMLERİNİN UYGULANMASI

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Abstract

The variability in customer demands necessitates careful monitoring of production processes. At this point, supplier selection, which is the first and most important stage of production, gains importance. However, the supplier selection problem is affected by many criteria with different weights depending on the production area. In addition, in today's intense competition, such problems are too important to be left to the intuition of the parties. In this case, multi-criteria decision making techniques, which have provided significant convenience for decision makers in recent years, are very useful.

In this context, the most suitable one among 5 supplier candidates was selected in the study. As a result of the literature research, the criteria affecting the problem; C1-delivery time (days), C2-product unit price (TL), C3-product defect rate (/100 shipments), C4-corporate structure (1-9), C5-economic strength (1-9), C6- logistics location (km.), C7-product quality (1-9) and C8-flexibility (1-9) and necessary information for alternatives were collected. Thus, the criteria in the initial matrix created were weighted with the SWARA technique. Finally, alternative suppliers were listed using COPRAS and OCRA methods and the most suitable supplier was selected.

In the study, the criteria were weighted with the SWARA technique based on three different expert opinions, and the accuracy of the results was confirmed by using the COPRAS and OCRA techniques together, and the reliability of the methods in terms of the results they produced was demonstrated. As a result, it has been determined that the methods used in ranking the alternatives are in harmony with each other and the results are reliable.

Keywords: *Supplier Selection, Multi-Criteria Decision-Making Methods, SWARA, COPRAS, OCRA.*

Öz

Müşteri taleplerindeki değişkenlik, üretim süreçlerini dikkatle izlemeyi zorunlu kılmaktadır. Bu noktada üretimin ilk ve en önemli aşaması olan tedarikçi seçimi önem kazanmaktadır. Ancak tedarikçi seçim problemi, üretim alanına bağlı olarak, birbirinden farklı ağırlıklardaki birçok kriterden etkilenmektedir. Ayrıca rekabet yoğun yaşanan günümüzde bu tür problemler, tarafların sezgilerine bırakılamayacak kadar da önemlidir. Bu durumda son yıllarda karar

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vericiler için önemli kolaylıklar sağlayan çok kriterli karar verme teknikleri oldukça kullanışlıdır.
Bu kapsamda çalışmada, 5 tedarikçi adayı arasından en uygun olanının seçim yapılmıştır. Literatür araştırması sonucunda, probleme etki eden kriterler; K1-tedarik süresi (gün), K2-ürün birim fiyatı (TL), K3-ürün hata oranı (/100 gönderi), K4-kurumsal yapı (1-9), K5-ekonomik güç (1-9), K6-lojistik konum (km.), K7-ürün kalitesi (1-9) ve K8-esneklik (1-9) şeklinde belirlenmiş ve alternatifler için gerekli bilgiler toplanmıştır. Böylece oluşturulan başlangıç matrisindeki kriterler SWARA tekniğiyle ağırlıklandırılmıştır. Nihayet COPRAS ve OCRA yöntemleriyle alternatif tedarikçiler arasından en uygun tedarikçi seçilmiştir.
Çalışmada kriterler üç farklı uzman görüşüne dayalı SWARA tekniğiyle ağırlıklandırılmış, COPRAS ve OCRA teknikleri birlikte kullanılarak hem sonuçların doğruluğu teyit edilmiş hem de yöntemlerin, ürettikleri sonuçlar açısından güvenilirlikleri ortaya konmuştur. Sonuç olarak alternatiflerin sıralanmasında kullanılan yöntemlerin birbiriyle uyum içerisinde oldukları ve sonuçları güvenilir olduğu belirlenmiştir.

Anahtar Kelimeler: *Tedarikçi Seçimi, Çok Kriterli Karar Verme Teknikleri, SWARA, COPRAS, OCRA.*

1. INTRODUCTION

One of the most crucial issues for businesses is to deliver the right product, in the right quantity, at the right time, at the right place, at an affordable price. Achieving this depends on cooperating with the right supplier, one of the significant links in the supply chain. Suppliers, which are at the beginning of the supply chain process and are one of the most important force multipliers, are the key to a healthy operation of a business, affecting the whole process after it. In this context, the significant decision points for businesses are determining the right suppliers and ensuring sustainable relations.
However, the supplier selection decision is under the influence of many criteria. Although it varies according to the sector, the importance levels of these criteria are also quite different from each other. In this case, it is challenging for the decision-maker to make a rational decision by considering all these criteria. Because the increase in the number of criteria will cause the issues to be considered to become more complex and a wrong decision to be taken under these conditions will bring all the functions of the business to a standstill at the very beginning and break the competitive power.
Many decision support systems have been put forward to support decision makers to overcome these difficulties and to act rationally away from intuitiveness, and these systems have made significant developments. At the beginning of these systems, there are multi-criteria decision-making methods, each of which ensures that a decision to be made under the influence of many criteria with different weights is rational by placing it on a scientific basis.
Multi-criteria decision-making methods, most of which provide ease of application and are therefore preferred, are the general name of the methods that consider all the criteria and weight values that affect the decision and support the decision maker in making the right decision. Although the application results of these methods are significantly similar to each other, it is not possible to compensate for a possible error that can be made in the analysis made with a single method in order to make a wrong decision. Therefore, hybrid analyzes (applications with more than one method), which have become widespread in the literature recently, do not only mean providing the results, but also support the reliability of the methods.

In this context, three different methods were used in the study. The first of these, SWARA (Step-wise Weight Assessment Ratio Analysis) method was used to determine the weight values of the criteria. Accordingly, as a result of the literature research; 8 criteria, 5 of which are maximization-oriented and 3 are minimization-oriented, which can affect the decision of the most appropriate supplier selection, were determined and the weights of these criteria were determined by a consensus solution by taking the opinions of 3 different experts. Thus, heuristic approaches in criterion weighting, which is the most criticized aspect of multi-criteria decision-making methods, are prevented.

In the second stage, 5 supplier candidates were determined, and the criteria values of these suppliers and the criteria weight values determined by the SWARA method were used separately with the COPRAS (COmplex PRoportional ASsessment - Complex Proportional Assessment Method) and OCRA (Operational Competitiveness Rating) methods to determine the most suitable supplier. Thus, it is ensured that a possible erroneous application is prevented, and the results are compared, and the correctness of the decision made for the selection of the most suitable supplier is confirmed.

2. PREVIOUS STUDIES

In the literature, there are many supplier selection problem solutions made with multi-criteria decision-making methods. In this section, information is given about some of the studies that inspired the determination of the criteria for this study.

Cengiz Toklu et al. (2018) in their study using SWARA and WASPAS methods; They have solved the problem of choosing a supplier for the iron and steel industry according to the criteria listed as cost advantage, quality, on-time delivery, response time, supplier reliability, payment terms, compliance with the demand, supplier's geographic location, flexibility, way of shipping the goods, and past performance.

Aydın and Eren (2018) in their study, used the AHP-TOPSIS method for the supplier selection problem, which is among the strategic issues of the purchasing department, which directly affects the delivery and quality performance of the enterprises; they discussed the criteria of quality, cost, delivery, machinery, skilled labor and technical competence.

Can and Arıkan (2014) selected a subcontractor for a company from the defense industry in their study. In the study, AHP and PROMETHEE II methods were used together based on knowledge level, experience, time, transportation, guarantee and price criteria.

Karaatlı and Davras (2014) have solved a supplier selection problem for hotel businesses by using AHP and Goal Programming methods. In this study, price, product quality, delivery performance, reliability, ease of payment and reference criteria were used.

3. METHOD

To talk about the decision-making function, first, there must be a problem that requires decision-making, more than one alternative to the decision, and criteria and certain constraints that will affect the solution (Demirci, 2020).

Although decision making takes place in every aspect of life; Infrastructure problems, national and regional development problems, promotion and promotion problems, research and development problems, method and application problems, selection problems, and production decision problems are some of the decision-making areas that are not routine and require scientific support (Roy, 1996).

Decision-making in this context is defined as the process of determining different solution alternatives in the face of a problem faced by a decision-maker or a situation that may become a problem later and putting one or more of them into practice by choosing the most suitable one among them (Yaralıoğlu, 2004).

There is no general approach to different problem domains. However, the decision problem; is possible to examine in four main groups selection problem, ranking problem, classification problem, and definition problem (Roy, 1991). To this list, It would be appropriate to add the design problem, elimination problem, and discovery problem (Ishizaka and Nemery, 2013). In this context, decision-making methods; can be examined under the headings of single-purpose decision-making methods, decision support systems, and multi-criteria decision-making methods (Özbek, 2017).

Multi-criteria decision-making methods include approaches that include numerical solution methods, which are frequently used in many fields today. It is the basis for all decision-makers in a decision-making situation to consider all possible parameters that may affect the decision, as well as to make a rational decision rather than common sense (Demirci, 2019-a). Because most of the decisions taken in daily life are affected by many criteria at different levels of importance. Therefore, the decisions are taken by different people on the same issue also differ from each other. The decision-making problem, which becomes more complex depending on the number of criteria, becomes more complex if these criteria affect each other. The abandonment of certain criteria to meet some conditions and the issue of which ones they will be will also vary from person to person and will make the decision-making activity much more inextricable. At this point, the use of multi-criteria decision-making methods enables decision problems to be handled in small parts and greatly facilitated and they significantly help decision-makers to make more rational decisions (Demirci, 2019-b).

In this context, in the study; Three different multi-criteria decision-making methods, which have been frequently used in the last period, will be introduced with an application. Among these methods, the SWARA method was used to weigh the criteria affecting the decision, and these weight values were applied separately with the COPRAS and OCRA methods, and the priority order of the alternatives was obtained.

3.1. SWARA

Step-wise Weight Assessment Ratio Analysis (SWARA) ~~is~~ a method used for weighting criteria based on expert opinion.

The method was first proposed by Kersuliene, Zavadskas, and Turskis (2010) and is widely used. According to the SWARA method, the significant criterion is put in the first place, and the insignificant criterion is put in the last place. In cases that require the consensus of more than one expert, a similar ranking is obtained by taking the geometric mean of the weight values given by each expert for the criteria (Aghdaie et al., 2014; Hashemkhani et al., 2013).

The process steps to be done with the SWARA method, as in other multi-criteria decision-making methods, start with the determination of decision-makers and criteria. The actions to be taken later in the process can be listed as follows (Kersuliene and Turskis, 2011; Stanujkic et al., 2017; Chalekaee et al., 2019; Erdal, 2018).

Determination of Criterion Ranking Based on Expert Opinion: At this stage, all criteria determined to contribute to the solution are ranked starting from the most important according to expert opinion. Rankings made when more than one expert opinion is taken are formed by taking the geometric mean to represent the common decision.

Determining the Relative Importance Levels of All Criteria: At this stage, the criteria are compared with each other in pairs and the relative importance level of each criterion (s_j) is determined.

$\boldsymbol{k_j}$ **Determination of the Coefficient:** At this stage, the k_j coefficient is determined with the help of Equation 1.

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \tag{1}$$

$\boldsymbol{q_j}$ **Determining the Coefficient:** At this stage, the q_j coefficient is determined with the help of Equation 2.

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \tag{2}$$

Determining the Relative Weights of the Criteria: At this stage, the relative weights (w_j) of the criteria are determined with the help of Equation 3.

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \tag{3}$$

3.2. COPRAS

COmplex Proportional Assessment (COPRAS) propounded by Zavadskas et al. (1994). Although it is like the Weighted Sum method, it was developed in response to the weakness of the method, which only considers benefit-oriented criteria (Kaklauskas et al., 2006; Mousavi-Nasab and Sotoudeh-Anvari, 2017; Podvezko, 2011). In this respect, the basis of the COPRAS method is based on the maximization of the benefit criteria and the minimization of the cost criteria (Arslan, 2018).

The implementation stages of COPRAS management can be specified as follows (Özbek, 2017; Adar and Kılıçdelice, 2020; Hashemkhani Zolfani and Bahrami, 2014);

Determination of Decision Matrix: At this stage, a decision matrix of m x n dimensions, with m number of decision alternatives and n number of decision criteria (j = 1, 2, 3, …, n), is created, as can be seen in Equation 4.

$$X = \begin{matrix} x_{01} & x_{02} & \cdots & x_{0n} \\ x_{11} & x_{12} & \cdots & x_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{matrix} \tag{4}$$

Standardization of Decision Matrix: At this stage, first of all, the weights of the criteria should be determined and then the decision matrix should be normalized. According to this, Equation 5 is used to show the w_i criterion weights.

$$d_{ij} = \frac{x_{ij} w_j}{\sum_{i=1}^{m} x_{ij}} \tag{5}$$

Addition of Weighted Normalized Indices: At this stage, S_{+i} ve S_{-i} values are determined, respectively, with the help of Equation 6 for maximization-oriented criteria and Equation 7 for minimization-oriented criteria.

$$S_{+i} = \sum_{j=1}^{n} d_{+ij} \tag{6}$$

$$S_{-i} = \sum_{j=1}^{n} d_{-ij} \tag{7}$$

Calculating the Relative Importance of Alternatives: At this stage, all alternatives are compared with each other and their relative importance values (Q_i) are determined. The Q_i values determined as a result of the calculation with the help of Equation 8. are ordered from the largest to the smallest. The largest Q_i value is of the greatest relative importance.

$$Q_i = S_{+i} + \frac{S_{-min.} \sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{=1}^{m} \frac{S_{-min.}}{S_{-i}}} \tag{8}$$

Determining the Benefit Degree of the Alternatives: At this stage, the utility grade (N_i) of the alternatives is determined with the help of Equation 9. All alternatives are ranked from greatest to least, with the alternative with a utility rating of 100 being the best.

$$N_i = \left(\frac{Q_i}{Q_{maks.}}\right) * 100\% \tag{9}$$

3.3. OCRA

Operational Competitiveness Rating (OCRA) proposed by Parkan (1994) is used to solve efficiency measurement and productivity analysis problems (Ercan and Kundakçı, 2017). In addition to introducing a non-parametric approach, the method has the advantage of evaluating alternatives separately according to maximization and minimization criteria (Madić et al., 2016).

The application steps of the method are as follows (Parkan and Wu, 1999; Parkan and Wu, 2000; Coşkun and Özcan, 2016);

Description of the Problem: At this stage; With the decision alternatives, maximization-oriented output factors and minimization-oriented input factors (decision criteria) are determined.

Calculation of Unscaled Input Preference Index (i^k): The relative efficiency of all inputs to other inputs is calculated with the help of Equation 10, considering only input factors.

$$i^k = \sum_{m=1}^{M} a_m \frac{\max_{n=1,\ldots,K}(X_m^n) - X_m^k}{\min_{n=1,\ldots,K}(X_m^n)} \quad ; \quad \begin{matrix} \forall n = 1, \ldots, K \\ X_m^n > 0 \\ \forall k = 1, \ldots, K \end{matrix} \tag{10}$$

Calculation of the Scaled Input Preference Index (I^k): At this stage, the degree of preference of one decision alternative relative to the others must be determined. For this, the unscaled input preference index is scaled with the help of Equation 11.

$$I^k = i^k - \min_{n=1,\ldots,K} i^n \quad ; \quad \forall k = 1, \ldots, K \tag{11}$$

Calculation of the Unscaled Output Preference Index (o^k): At this stage, the preference of the alternatives according to the output variable is determined and the unscaled output preference index is calculated with the help of Equation 12.

$$o^k = \sum_{h=1}^{H} b_n \frac{Y_h^k - \min_{n=1,\ldots,K}(Y_h^n)}{\min_{n=1,\ldots,K}(X_h^n)} \quad ; \quad \begin{matrix} \forall n = 1, \ldots, K \\ Y_h^n > 0 \\ \forall k = 1, \ldots, K \end{matrix} \tag{12}$$

Calculation of the Scaled Output Preference Index (O^k): At this stage, the same procedure is followed to determine the scaled input preference index. Thus, the preference status of any alternative is determined by considering the output variables. Equation 13. is used for this.

$$O^k = o^k - \min_{n=1,\dots,K} o^n \quad ; \quad \forall k = 1, \dots, K \tag{13}$$

Calculation of the Unscaled General Preference Index (e^k): At this stage, the unscaled general preference index is calculated with the help of Equation 14. The unscaled overall preference index is the sum of the scaled input preference index of the alternatives and the scaled output preference index.

$$e^k = I^k + O^k \quad ; \quad \forall k = 1, \dots, K \tag{14}$$

Calculation of the Scaled General Preference Index (E^k): At this stage, the scaled general preference index calculated with the help of Equation 15. expresses the difference between the unscaled general preference index for each alternative and the smallest unscaled general preference index belonging to the alternative set. The values determined as a result of the calculation are ordered from largest to smallest, and the alternative with the highest value is considered to have the best efficiency value.

$$E^k = I^k + O^k - \min_{n=1,\dots,K} (I^n + O^n) \quad ; \quad \forall k = 1, \dots, K \tag{15}$$

4. ANALYSIS AND RESULTS

The criteria that were considered to be effective in the selection of suppliers for the sample application of the study were determined as a result of the literature review and were weighted with the SWARA method based on the opinions of three experts. In this context, the criteria used in the study are; C1-storage possibilities (1-9), C2-recycling possibilities (1-9), C3-production possibilities (1-9), C4-packaging possibilities (1-9), C5-environmental awareness (1-9), C6-logistics costs (TL.), C7-product costs (TL.), C8-delivery time (average hours) and C9-misdelivery situation (1-9). The initial matrix consisting of the criteria values of the 5 suppliers determined to choose between them is presented in Table 1.

Table 1. Decision Matrix

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
Criteria Direction	Max.	Max.	Max.	Max.	Max.	Min.	Min.	Min.
Scale	1-9	1-9	1-9	1-9	1-9	TL.	TL.	Hour
Company 1	6	9	7	8	8	76	90	16
Company 2	8	6	4	9	7	78	91	18
Company 3	9	5	9	7	9	80	89	19
Company 4	7	8	6	7	6	81	88	14
Company 5	9	3	8	9	7	76	90	16

For the SWARA application, which is used to determine the weights of the criteria, separate analyzes were made according to the opinions of 3 experts. In this way, it is aimed to eliminate the possibility of a single decision maker being biased. Accordingly, SWARA Parameter Values obtained by following the SWARA process steps; It is presented in Table 2-4.

Table 2. Parameter Values Defined by Decision Maker 1

Criteria	Order of importance	Rank		s_j	k_j	q_j	w_j
C1	6	C3	1		1.0000	1.0000	0.1745
C2	5	C6	2	0.1000	1.1000	0.9091	0.1586

C3	1	C7	3	0.2000	1.2000	0.7576	0.1322
C4	8	C5	4	0.0500	1.0500	0.7215	0.1259
C5	4	C2	5	0.0800	1.0800	0.6681	0.1166
C6	2	C1	6	0.1400	1.1400	0.5860	0.1022
C7	3	C8	7	0.0600	1.0600	0.5528	0.0965
C8	7	C4	8	0.0300	1.0300	0.5367	0.0936

Table 3. Parameter Values Defined by Decision Maker 2

Criteria	Order of importance	Rank		s_j	k_j	q_j	w_j
C1	1	C1	1		1.0000	1.0000	0.1659
C2	3	C7	2	0.1100	1.1100	0.9009	0.1494
C3	5	C2	3	0.0800	1.0800	0.8342	0.1384
C4	4	C4	4	0.0300	1.0300	0.8099	0.1343
C5	7	C3	5	0.0500	1.0500	0.7713	0.1279
C6	6	C6	6	0.1500	1.1500	0.6707	0.1112
C7	2	C5	7	0.1800	1.1800	0.5684	0.0943
C8	8	C8	8	0.2000	1.2000	0.4737	0.0786

Table 4. Parameter Values Defined by Decision Maker 3

Criteria	Order of importance	Rank		s_j	k_j	q_j	w_j
C1	2	C5	1		1.0000	1.0000	0.1953
C2	7	C1	2	0.2000	1.2000	0.8333	0.1628
C3	8	C6	3	0.1800	1.1800	0.7062	0.1379
C4	6	C8	4	0.1400	1.1400	0.6195	0.1210
C5	1	C7	5	0.1200	1.1200	0.5531	0.1080
C6	3	C4	6	0.1000	1.1000	0.5028	0.0982
C7	5	C2	7	0.0800	1.0800	0.4656	0.0909
C8	4	C3	8	0.0600	1.0600	0.4392	0.0858

In this last stage of the SWARA method, the geometric average of the w_j values determined by the 3 decision makers was taken and the consensus weight values were determined for the criteria. The criteria weight values obtained as a result of this process are presented in Table 5.

Table 5. Criteria Weights

Criteria	DM1 w_j	DM2 w_j	DM3 w_j	Weight Value. Geo.Mean	Order of importance
C1	0.1022	0.1659	0.1628	0.1403	5
C2	0.1166	0.1389	0.0909	0.1138	7
C3	0.1745	0.1279	0.0858	0.1242	6
C4	0.0936	0.1343	0.0982	0.1073	8
C5	0.1259	0.5684	0.1953	0.2409	2
C6	0.1586	0.6707	0.1379	0.2448	1
C7	0.1322	0.9009	0.1080	0.2343	3
C8	0.0965	0.4737	0.1210	0.1769	4

These criteria weights determined by the SWARA method were used in two different multi-criteria decision-making methods (COPRAS and OCRA). For this, first the application stages of the COPRAS method were completed and the ranking of the alternatives was obtained. According to this, Using the Initial Matrix presented in Table 1 and the criterion weights presented in Table 5, the Weighted and Normalized Matrix was obtained and presented in Table 6.

Table 6. Weighted and Normalized Matrix

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
Company 1	0.0216	0.0330	0.0256	0.0215	0.0521	0.0476	0.0471	0.0341
Company 2	0.0288	0.0220	0.0146	0.0241	0.0456	0.0488	0.0476	0.0384
Company 3	0.0324	0.0183	0.0329	0.0188	0.0586	0.0501	0.0465	0.0405
Company 4	0.0252	0.0294	0.0219	0.0188	0.0391	0.0507	0.0460	0.0298
Company 5	0.0324	0.0110	0.0292	0.0241	0.0456	0.0476	0.0471	0.0341

Then, the necessary COPRAS Parameters were obtained by following the COPRAS application steps and finally the alternatives were listed. COPRAS Parameters and rank values of alternatives are presented in Table 7.

Table 7. COPRAS Parameters' and Rank Values od Alternatives

	S_{+i}	S_{-i}	S_{-min}	$\sum S_{-min}$	$\frac{S_{-min}}{S_{-i}}$	$\sum \frac{S_{-min}}{S_{-i}}$	Q_i	N_i	Rank
Comp.1	0.1287	0.1537	0.1343	0.7264	0.8736	4.6454	0.2653	0.9144	5
Comp.2	0.1348	0.1351			0.9939		0.2902	1.0000	1
Comp.3	0.1372	0.1610			0.8343		0.2676	0.9221	4
Comp.4	0.1266	0.1343			1.0000		0.2829	0.9750	2
Comp.5	0.1287	0.1423			0.9436		0.2763	0.9521	3

In the application of the OCRA method, the Initial Matrix presented in Table 1 and the criterion weights presented in Table 5 were used, and the application stages of the OCRA method were followed respectively. The Unscaled Input and Output Preference Indexes calculated accordingly are presented in Table 8.

Table 8. Unscaled Input and Output Preference Indexes

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
Company 1	0.0701	0.0000	0.0621	0.0153	0.0401	0.0161	0.0027	0.0379
Company 2	0.0234	0.1138	0.1552	0.0000	0.0803	0.0097	0.0000	0.0126
Company 3	0.0000	0.1517	0.0000	0.0306	0.0000	0.0032	0.0053	0.0000
Company 4	0.0468	0.0379	0.0931	0.0306	0.1204	0.0000	0.0080	0.0632
Company 5	0.0000	0.2275	0.0310	0.0000	0.0803	0.0161	0.0027	0.0379

Finally, the scaled input preference index, scaled output preference index, unscaled general preference index and scaled general preference index, which are the parameters of the OCRA method, were calculated and presented in Table 9 with the rankings of the alternatives made accordingly.

Table 9. OCRA Parameters' and Rank Values of Alternatives

	Scaled Input Preference Index		Scaled Output Preference Index		Unscaled General Preference Index	Scaled General Preference Index	Rank
Company 1	0.1877	0.0054	0.0085	0.0085	0.0139	0.0000	5
Company 2	0.3727	0.1903	0.0711	0.0711	0.2615	0.2476	1
Company 3	0.1823	0.0000	0.0567	0.0567	0.0567	0.0427	4
Company 4	0.3289	0.1466	0.0000	0.0000	0.1466	0.1327	3
Company 5	0.3389	0.1565	0.0000	0.0000	0.1565	0.1426	2

Since 8 different criteria affecting the supplier selection decision were determined, the most suitable supplier was selected among 5 alternatives for a company by using multi-criteria decision-making methods. For this, criteria weights were determined first, and 5 supplier candidates were ranked using COPRAS and OCRA methods. The resulting ranking of alternatives is presented in Table 10. Accordingly, the most suitable company was determined as "Company 2" with both methods. While the second and third ranks changed between "Company 4" and "Company 5" according to the methods, "Company 3" took the fourth place and "Company 1" took the fifth place.

Table 10. Rank of Alternatives by COPRAS and OCRA Methods

	COPRAS Rank Values	OCRA Rank Values
Company 1	**5**	**5**
Company 2	**1**	**1**
Company 3	**4**	**4**
Company 4	**2**	**3**
Company 5	**3**	**2**

One of the most important results of the study is that different multi-criteria decision-making methods gave very close results to each other. Of course, it is also possible to conclude similar studies with a single method. However, this may lead to the researchers not being aware of a possible mistake made during the implementation phase and thus making wrong decisions that cannot be compensated. The repetition of similar studies with more than one multi-criteria decision-making method will not only confirm the accuracy of the decision but also allow the comparison of the methods to give healthy results.

In this context, researchers in future studies; can use different multi-criteria decision-making methods with different weight values by considering different criteria and comparing the results by repeating the study.

5. CONCLUSIONS

In the study, since 8 different criteria affecting the supplier selection decision were determined, the most suitable supplier was selected among 5 alternatives for a company by using multi-criteria decision-making methods. For this purpose, firstly, criteria weights were determined, and then 5 supplier candidates were ranked using COPRAS and OCRA methods. Accordingly, the most suitable company was determined as “Company 2” by both methods. While the second and third ranks changed between "Company 4" and "Company 5", "Company 3" took the fourth rank, and "Company 1" took the fifth rank.

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