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# A Comparative Analyze Based On EATWOS and OCRA Methods For Supplier Evaluation

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ADCTDACT	
ABSIRALI	In the conditions of increasing competition, the methods of evaluating and selecting suppliers which are one of the most
	important part of the supply chains have gained importance for the companies. To evaluate the potential or current suppliers,
	applying quantitative analysis can be helpful for the company management. In this paper, efficiencies of suppliers are evaluated
	with EATWOS (Efficiency Analysis Technique With Output Satisficing) and OCRA (Operational Competitiveness RAting) methods.
	The ranking of the suppliers are determined based on their efficiency scores then the obtained results are compared.
Keywords:	Supplier Evaluation, Efficiency, EATWOS, OCRA

# Tedarikçi Değerlendirmesinde EATWOS ve OCRA Yöntemlerine Dayalı Karşılaştırmalı Bir Analiz

ÖZ	Artan rekabet koşullarında, tedarik zincirinin en önemli parçalarından biri olan tedarikçileri değerlendirme ve seçme yöntemleri
	şirketler için önem kazanmıştır. Potansiyel veya mevcut tedarikçileri değerlendirmek için, nicel analizlerin uygulanması şirket
	yönetimine yardımcı olabilir. Bu yazıda, tedarikçilerin verimliliği EATWOS ve OCRA yöntemleri ile değerlendirilmiştir. Tedarikçilerin
	sıralaması verimlilik puanlarına göre belirlenmiş ve elde edilen sonuçlar karşılaştırılmıştır.
Anahtar Kelimeler:	Tedarikçi Değerlendirme, Etkinlik, EATWOS, OCRA



## 1. Introduction

Supplier evaluation is the process of assessing the potential or current suppliers by using quantitative analysis. It is also a process used to evaluate current suppliers in order to measure their performance in the aims of reducing cost and improving themselves. In the literature quantitative analysis are proposed to evaluate the suppliers. According to the results of the evaluation process the purchasing manager and company management can decide to establish long term relationships with existing suppliers or seek new ones. Besides, if these evaluation results are shared with the suppliers, they can also improve themselves by recognizing their current status. By this way, both companies and their suppliers can reduce costs and increase profitability. On the other hand, evaluation of supplier performance helps companies to restructure their supply network.

The subject of supplier evaluation and selection is an area that continues to attract attention in the literature and it has been studied extensively. In this evaluation process, quantitative techniques like Data Envelopment Analysis (DEA), mathematical programming, Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), fuzzy set theory, Simple multi-attribute rating technique, Genetic algorithm and other integrated approaches are proposed. A detailed literature review about supplier evaluation can be found in the article of Ho et al. (2010). The novelty of this paper from others in the literature, EATWOS and OCRA methods are applied to supplier evaluation and the obtained results are compared.

The rest of this paper is organized as follows. After a brief introduction section, EATWOS method is introduced and its steps are summarized in the second section. In section three, OCRA method is explained. Section four presents the application. The last section concludes the paper, at the same time in this section suggestions for future studies are also given.

# 2. EATWOS Method

EATWOS method was firstly proposed by Peters and Zelewski (2006). It is an efficiency analysis method based on satisficing concept and supports the decision-making unit to lead to satisfactory solutions instead of optimum solutions (Peters and Zelewski, 2006). This method has been implemented in different fields to measure the efficiencies. For example it has been used in performance evaluation of vendors of a packaged drinking water manufacturer and distributer (Bansal et al., 2014), analyzing private pension companies in Turkey (Özbek, 2015a), measuring the efficiency of Turkish Red Crescent Society (Özbek, 2015b), analyzing the efficiency of five non-governmental organizations in Turkey (Özbek, 2015c), ranking the players of the Indian Premier League based on the statistics of 2013 season (Kumar et al., 2016) efficiency analysis of gold production companies by using financial statements of the companies between 2008 and 2015 (Özbek, 2016), efficiency analysis of a charity organization (Özbek, 2018).

In EATWOS method, decision makers have the opportunity of determining satisficing levels for outputs. In this paper, EATWOS method without consideration of satisficing levels is used. The steps of the EATWOS method without consideration of satisficing levels can be given as (Peters and Zelewski, 2006):



**Step 1.** In the first step, inputs and outputs are determined by the decision makers. Later, decision making units (DMUs) are clarified. Then, the output matrix  $\underline{Y}$  and input matrix  $\underline{X}$  are constructed by using the output quantities  $y_{ij}$  and input quantities  $x_{ik}$  for all DMUs.

$$\underline{Y} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1j} & \cdots & y_{1J} \\ y_{21} & y_{22} & \cdots & \cdots & y_{2J} \\ \cdots & \cdots & & & \ddots & \\ y_{i1} & y_{i2} & \cdots & y_{ij} & \cdots & y_{iJ} \\ \cdots & \cdots & & & \\ y_{I1} & y_{I2} & \cdots & y_{Ij} & \cdots & y_{IJ} \end{bmatrix} \quad y_{ij} \in R_{\geq 0} \quad \forall i = 1, \dots, I, \quad \forall j = 1, \dots, J$$
(1)

In this matrix, DMUs are placed on the rows and outputs are placed on the columns. Later, input matrix  $\underline{X}$  is constructed and in this matrix, DMUs are placed on the rows and inputs are placed on the columns.

$$\underline{X} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1k} & \dots & x_{1K} \\ x_{21} & x_{22} & \dots & \dots & x_{2K} \\ \dots & \dots & & & \dots & \\ x_{i1} & x_{i2} & \dots & x_{ik} & \dots & x_{iK} \\ \dots & \dots & & & & \\ x_{I1} & x_{I2} & \dots & x_{Ik} & \dots & x_{IK} \end{bmatrix} x_{ik} \in R_{\ge 0} \quad \forall i = 1, \dots, I, \quad \forall k = 1, \dots, K$$

$$(2)$$

**Step 2.** After constructing input and output matrices, output quantities  $y_{ik}$  and input quantities  $x_{ik}$  are normalized by using Eq. (3) and Eq. (4) respectively.

The normalization formula for outputs:

$$\exists i, \ \exists j \qquad y_{ij} \neq 0 \quad r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{l} y_{ij}^2}} \qquad \forall i = 1, \dots, I \quad \forall j = 1, \dots, J$$
(3)  
$$\forall i = 1, \dots, I \quad \forall j = 1, \dots, J \qquad y_{ij} = 0 \qquad r_{ij} = 0$$

Here,  $y_{ij}$  is squared to avoid the denominator getting zero value.

The normalization formula for inputs:

$$\exists i, \ \exists k \qquad x_{ik} \neq 0 \qquad s_{ik} = \frac{x_{ik}}{\sqrt{\sum_{i=1}^{l} x_{ik}^2}} \qquad \forall i = 1, \dots, I \quad \forall k = 1, \dots, K$$

$$\forall i = 1, \dots, I \quad \forall k = 1, \dots, K \qquad (4)$$

$$x_{ik} = 0 \qquad s_{ik} = 0$$

Later, normalized output matrix  $\underline{R}$  and normalized input matrix  $\underline{S}$  are constructed as given in Eq. (5) and Eq. (6) respectively.

$$\underline{R} = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1j} & \dots & r_{1j} \\ r_{21} & r_{22} & \dots & \dots & r_{2j} \\ \dots & \dots & & & \dots & \\ r_{i1} & r_{i2} & \dots & r_{ij} & \dots & r_{ij} \\ \dots & \dots & & & & \\ r_{i1} & r_{i2} & \dots & r_{ij} & \dots & r_{ij} \end{bmatrix}$$
(5)



 $\boldsymbol{\underline{S}} = \begin{bmatrix} s_{11} & s_{12} & \dots & s_{1k} & \dots & s_{1K} \\ s_{21} & s_{22} & \dots & & \dots & s_{2K} \\ \dots & \dots & & & & \dots & \\ s_{i1} & s_{i2} & \dots & s_{ik} & \dots & s_{iK} \\ \dots & \dots & & & & \\ s_{I1} & s_{I2} & \dots & s_{Ik} & \dots & s_{IK} \end{bmatrix}$ (6)

**Step 3.** In the normalized output matrix <u>R</u> considering column vectors  $\vec{r_j}$ , maximum normalized output quantities  $r_j^*$  are determined for each output *j* with the help of Eq. (7).

$$r_j^* = \max\{\vec{r}_j\} \quad \forall j = 1, \dots, J$$
(7)

Later, in the normalized input matrix  $\underline{S}$  considering column vectors  $\vec{s_k}$ , minimum normalized input quantities  $s_k^*$  are determined for each input k by using Eq. (8).

$$s_k^* = \min_{i} \{ \overline{s_k} \} \quad \forall k = 1, \dots, K$$
(8)

**Step 4.** For the outputs, distance measures  $op_{ij}$  are determined with the help of Eq. (9) considering matrix <u>R</u> and the maximum normalized output quantities  $r_j^*$ . The distance measure  $op_{ij}$  is taken as output score.

$$op_{ij} = 1 - (r_i^* - r_{ij}) \quad \forall i = 1, ..., I \quad \forall j = 1, ..., J$$
 (9)

Later, for the inputs distance measures  $ip_{ik}$  are determined via Eq. (10) considering matrix  $\underline{s}$  and the minimum normalized input quantities  $s_k^*$ . The distance measure  $ip_{ik}$  is taken as input score.

$$ip_{ik} = 1 + s_{ik} - s_k^* \quad \forall i = 1, ..., I \quad \forall k = 1, ..., K$$
 (10)

*Step 5.* Finally, efficiency scores for each DMUs are calculated by using Eq. (11).

$$E_{i} = \frac{\sum_{j=1}^{J} v_{j} * o_{pj}}{\sum_{k=1}^{K} w_{k} * i_{pk}} \quad \forall i = 1, \dots, I$$
(11)

Here,  $v_j$  shows the relative importance weight of outputs wheras  $w_k$  shows the relative importance weight of inputs. These importance weights can be determined by using AHP, entropy method, SWARA or MACBETH.

Low efficiency score  $E_i$  means lower efficiency relative to the other DMUs and reversely, a high efficiency score  $E_i$  means a high efficiency. At the end, DMUs are ranked according to their efficiency scores in descending order.

### 3. OCRA Method

The OCRA (**O**perational **C**ompetitiveness **RA**ting) method was firstly proposed by Parkan in 1994. It is a relative performance measurement method and based on a nonparametric model. OCRA method is very useful to compare different decision making units and analyze different sectors. Another important feature of OCRA method is its ability to monitor and compare the performances of decision units over time.



In the literature, OCRA method has been successfully applied to various areas. For instance it was used in measuring the service performance of a subway system (Parkan, 1996a), evaluating the operational competitiveness profile of the hotels (Parkan, 1996b), selecting process for a semiconductor manufacturer according to their operational benefits (Parkan and Wu, 1996), competitive analysis of food processing industry's manufacturing plants (Jayanthi et al., 1996; 1999), measuring the operational performance of the software development teams of a bank (Parkan et al., 1997), process selection in a manufacturing sector (Parkan and Wu, 1998), measurement of the investment bank's performance (Parkan and Wu , 1999a), analyzing the relative operational performance of manufacturing industries in Hong Kong between the years 1987 and 1993 (Parkan and Wu, 1999b), solving robot selection problem (Parkan and Wu, 1999c), process selection (Parkan and Wu, 2000), evaluating the public transport company's performance (Parkan, 2002), measuring the drugstores' relative performances (Parkan, 2003), analyzing the Hungarian food industry's performance (Tóth, 2005), comparison of the two hotels' operational performance (Parkan, 2005), obtaining technical efficiency scores of farms in Bulgaria (Bakucs et al., 2011), solving a gear material selection problem (Chatterjee and Chakraborty, 2012) selecting facility location (Chakraborty et al., 2013), decisionmaking in manufacturing applications (Chatterjee, 2013), selection of flexible manufacturing system (Chatterjee and Chakraborty, 2014), material selection in sugar industry (Darji and Rao, 2014), selecting the most suitable nonconventional machining process (Madić et al., 2015), measuring the performances of foreigncapital banks (Özbek, 2015d), evaluating the performance of Turkish public banks (Özbek, 2015e), measuring the performances of foreign-capital banks (Özbek, 2015f), evaluating the hotel alternatives (Tuş Işık and Aytaç Adalı, 2016).

The steps of the OCRA method can be given as (Parkan and Wu, 2000; Chatterjee and Chakraborty, 2012):

**Step 1:** Firstly inputs, outputs and decision making units (DMUs) are determined by the decision makers. Then, output matrix  $\underline{Y}$  and input matrix  $\underline{X}$  are constructed as seen in Eq. (1) and Eq. (2).

Step 2: Then unscaled input indices are calculated by using Eq. (12):

$$\overline{I}_{i} = \sum_{k=1}^{K} w_{k} \frac{\max(x_{ik}) - x_{ik}}{\min(x_{ik})} \qquad (i = 1, 2, ..., I k = 1, 2, ..., K)$$
(12)

Here *K* is the number of input and  $w_k$  is the weight of input *k*.

*Step 3:* In the third step, input indices are scaled via Eq. (13).

$$\overline{I}_i = \overline{I}_i - \min(\overline{I}_i) \tag{13}$$

Step 4: In the fourth step, unscaled output indices are calculated by using Eq. (14):

$$\overline{O}_{i} = \sum_{j=1}^{J} v_{j} \frac{x_{ij} - \min(x_{ij})}{\min(x_{ij})} \qquad (i = 1, 2, ..., I \ j = 1, 2, ..., J)$$
(14)



Here *J* shows the number of outputs and  $v_j$  is the importance weight of output *j*.  $\sum_{k=1}^{K} w_k + \sum_{j=1}^{J} v_j = 1$  equality must be ensured. In other words, the sum of the weights of inputs and outputs must equal to one.

inputs and outputs must equal to one.

Step 5: In the fifth step, output indices are scaled by using Eq. (15).

$$\overline{O}_i = \overline{O}_i - \min(\overline{O}_i)$$
(15)

*Step 6:* Finally, the scaled efficiency indices for each DMUs are calculated via Eq. (16) and the DMU that has the lowest efficiency will take the value of zero.

$$E_{i} = (\bar{I}_{i} + \bar{O}_{i}) - \min(\bar{I} + \bar{O}) \quad i = 1, 2, ..., m$$
(16)

Alternatives are ranked according to their scaled efficiency indices in descending order.

#### 4. Application

In this part, supplier evaluation problem of Talluri and Narasimhan (2003) is considered. The same problem is solved with EATWOS and OCRA methods and then the obtained results are compared. In this supplier evaluation problem, six suppliers will be evaluated. In the evaluation process price is considered as input whereas acceptance and on time deliveries are outputs. The data of these six suppliers are given on Table 1.

	Input	Output	
Suppliers	Price (\$/unit)	Acceptance (%)	On Time Deliveries (%)
S <sub>1</sub>	0.1958	98.8	95
S₂	0.1881	99.2	93
S₃	0.2204	100	100
S <sub>4</sub>	0.2081	97.9	100
S₅	0.2118	97.7	97
S <sub>6</sub>	0.2096	98.8	96

**Table 1.** Data of the suppliers

Firstly, suppliers are evaluated by using EATWOS method. According to this method, output and input quantities are normalized with the help of Eq. (3) and Eq. (4). These normalized values are given on Table 2.

	Input	Output	
Suppliers	Price (\$/unit)	Acceptance (%)	On Time Deliveries (%)
S <sub>1</sub>	0.3882	0.4099	0.4004
S₂	0.3729	0.4115	0.3920
S₃	0.4370	0.4149	0.4215
S <sub>4</sub>	0.4126	0.4062	0.4215
S₅	0.4199	0.4053	0.4088
S <sub>6</sub>	0.4156	0.4016	0.4046
	0.3729	0.4149	0.4215

Table 2. Normalized input and output values

After normalized input and output values are calculated, maximum normalized output quantities and minimum normalized input quantity are determined via Eq. (7) and Eq (8) respectively. These values can be seen at the last row of the Table 2.

Later distance measures for the outputs and inputs are calculated by using Eq. (9) and Eq. (10). These obtained values are summarized on Table 3.



	Input	Output	Output	
Suppliers	Price	Acceptance	On Time Deliveries	
S₁	1.0153	0.9950	0.9789	
S₂	1.0000	0.9967	0.9705	
S₃	1.0640	1	1	
<b>S</b> 4	1.0397	0.9913	1	
S₅	1.0470	0.9905	0.9874	
S <sub>6</sub>	1.0426	0.9867	0.9831	
Weights	1	0.5	0.5	

 Table 3. Distance measures

Lastly, input and output distance measures are utilized to obtain an efficiency score for each decision making unit via Eq. (11) as seen in Table 4. Then suppliers are ranked according to these efficiency scores in descending order.

	Input
Suppliers	Price
S₁	0.9721
S₂	0.9836
S₃	0.9398
S <sub>4</sub>	0.9577
S₅	0.9445
S <sub>6</sub>	0.9447

Table 4. Efficiency scores of suppliers

According to the effciency scores of the suppliers, their ranking is obtained as  $S_2 > S_1 > S_4 > S_5 > S_3$ . The same ranking is obtained with Talluri and Narasimhan (2003).

After the ranking of suppliers according to their efficiencies with EATWOS method is obtained, OCRA method is used to evaluate them. In OCRA method, unscaled input indices are determined with the help of Eq. (12) by considering the data on Table 1. In OCRA method the sum of the weights of inputs and outputs must equal to 1. So in the calculation, the weight of  $I_1$  is taken as 0.5, and the weight of  $O_1$  is s 0.25 and weight of  $O_2$  is 0.25. The obtained values are given on Table 5.

Suppliers	<b>I</b> 1
S₁	0.0654
S₂	0.0859
S₃	0.0000
S <sub>4</sub>	0.0327
S₅	0.0229
S <sub>6</sub>	0.0287

Table 5. Unscaled input indices

Suppliers	li
S <sub>1</sub>	0.0654
S₂	0.0859
S₃	0.0000
<b>S</b> 4	0.0327
S₅	0.0229
S₅	0.0287

Table 6. Scaled input indices

Later, input indices are scaled with the help of Eq. (13) as seen in Table 6.

Then, unscaled output indices are determined by using Eq. (14) and given in Table 7.



Suppliers	01	<b>O</b> 2	Total
S <sub>1</sub>	0.0052	0.0054	0.0105
S₂	0.0062	0.0000	0.0062
S₃	0.0083	0.0188	0.0271
S4	0.0028	0.0108	0.0217
S₅	0.0023	0.0108	0.0131
S <sub>6</sub>	0.0000	0.0081	0.0081

Table 7. Unscaled output indices

Later, scaled output indices are calculated for outputs with the help of Eq. (15) as seen in Table 8.

Suppliers	<b>O</b> i
S₁	0.0043
S₂	0.0000
S₃	0.0209
S <sub>4</sub>	0.0155
S₅	0.0069
S <sub>6</sub>	0.0019

Table 8. Scaled output indices

Suppliers	Pi
S <sub>1</sub>	0.0489
S₂	0.0650
S₃	0.0000
S <sub>4</sub>	0.0273
S₅	0.0089
S <sub>6</sub>	0.0097

Table 9. Scaled efficiency indices

Suppliers are ranked according to their scaled efficiency indices. Then, the ranking of the suppliers according to their efficiencies with OCRA method is obtained as  $S_2 > S_1 > S_4 > S_5 > S_3$ . OCRA method obtained the same ranking with EATWOS method and Talluri and Narasimhan (2003).

### 5. Conclusion

Companies have to evaluate and select the appropriate suppliers for their supply chains in order to compete in today's dynamic and global markets. For this reason, evaluating the suppliers has an essential role for the companies. In this evaluation process various efficiency analysis can be used. In this paper, EATWOS and OCRA methods are proposed for this aim. The suppliers are firstly evaluated with EATWOS method. In the evaluation process input is determined as "price" and there are two outputs as "acceptance" and "on time deliveries". Six current suppliers of the suppliers according to their efficiencies with EATWOS method. The ranking of the suppliers according to their efficiencies with EATWOS method is obtained as 52 >51 >54 >56 >55 >53. Later the suppliers are also evaluated with OCRA method and the same raking is obtained with EATWOS method. The results indicate that these two methods are suitable for supplier evaluation.

In future studies other efficiency analysis like DEA can be used to evaluate the suppliers and the results can be compared. And the weights of inputs and outputs used in OCRA and EATWOS method can be determined by AHP, MACBETH, SWARA and entropy method. Lastly, EATWOS and OCRA methods can be used to evaluate



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Finally, the scaled efficiency indices for each supplier are calculated by using Eq. (16).

the efficiencies of different DMUs like branches of banks, schools, universities, companies that operate in the same sector etc..

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