A Comparative Analysis of TOPSIS and MOORA in Laptop Selection

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Abstract

A lot of criteria are influential in selection of a laptop computer due to the technological and global changes happening today and making a choice is becoming harder. In this study, criteria that are taken into consideration in laptop selection are evaluated using multi-criteria decision making methods according to the selections of students studying at Dumlupinar University, School of Applied Sciences, and Department of Insurance and Risk Management. 6 criteria and 11 brands are considered for laptop selection. Evaluations made by students and alternatives are analyzed with TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and MOORA (Multi-Objective Optimization on Basis of Ratio Analysis) methods and results are compared.

Keywords: Laptop Selection, Multi-Criteria Decision Making, MOORA, TOPSIS.

1.Introduction

Laptops have become an essential need for everyone in our day because they are technological needs for individuals and institutions, they are helpful both in business environments and in personal use, and they lower complexity and possibility of making mistakes. They have different versions and features such as netbook, ultrabook, tablet, smart computers etc. (Pekkaya and Aktogan, 2014: 108). As more different products and models emerge with the advancing technology, it is becoming harder for individuals to decide. In this study, some criteria are determined that will be helpful in laptop selection stage (Düzakın and Demirtaş, 2005: 265).

Decision makers need methodological tools along with traditional ways to select the suitable alternative among others in ambiguous and complicated situations during the daily life (Ertuğrul and Karakoşlu, 2010: 25). Laptops have many different features. The determinant factor changes depending on the choice of users in laptop selection. Selecting the most appropriate alternative among others by comparing all features is a multi-criteria decision making problem (Erpolat and Cinemre, 2011: 207-208).

Examining the literature, a lot of different application in many fields can be found by using only one multi-criteria decision making methods or using more than one method together. Some studies that have employed TOPSIS and MOORA methods together, which are the subjects of our research and basically similar to each other, are shown in Table 1.

Table 1: Studies in Which TOPSIS and MOORA Methods Are Used Together

Year	Author(s)	Subject
2012	Onur Önay, Eyüp Çetin	Determining the Popularity of Tourist Destinations: İstanbul Case
2013	DragisaStanujkic, BojanDjordjevic and Mira Djordjevic	Comparative Analysis of Some Prominent MCDM Methods
2015	Ali Şimşek, Ozan Çatır, Nuri Ömürbek	Supplier Selection
2015	Yusuf Tansel İç, MuhteşemTekin, Fazıl ZiyaPamukoğlu, S. ErdinçYıldırım	Development of a Financial Performance Benchmarking Model for Corporate Firms
2015	Priyank B Patel, Jaksan D. Patel, Kalpesh D. Maniya	Parameter Evaluation
2016	Blanca Ceballos, María Teresa Lamata, David A. Pelta	Comparative analysis of multi-criteria decision making methods
2016	Onur Önay	OECD Better Life Index
2016	Onur Önay, Bahadır Fatih Yıldırım	Statistical Regional Units Classification, Evaluation of Regions of Level 2

In this study, laptop selection problem of students studying at Dumlupinar University, School of Applied Sciences, Department of Insurance and Risk Management is dealt. Making the selection for the best laptop for students is aimed as a result of the study. To this end, MOORA and TOPSIS multi-criteria decision making methods are employed together in order to solve the laptop selection problem and the methods are compared. For the ranking of laptops according to the criteria, TOPSIS and MOORA methods are employed. Microsoft Excel 2013 software is used for the calculations of TOPSIS and MOORA methods.

The study consists of four sections. In the first section, general information about the subject and its importance and literature review is presented. In the second section, stages of multi-criteria decision making methods, TOPSIS and MOORA, are explained. In the third section, TOPSIS and MOORA methods are applied to the students in order to determine the most appropriate laptop. And, in the final section, conclusion and evaluation are made.

2. Material and Method
TOPSIS Method
In a situation with too many alternatives with multiple criteria for the evaluation, a lot of problems related to decision making process or selection of the best alternative may arise. There are various multi-criteria decision making methods to be used in that kind of multi-criteria decision making problems (Özdagoglu, 2013: 245). TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), which is one of the multi-criteria decision making methods and provide the possibility of choosing the best alternative, was developed by Yoon and Hwang in 1981 (Özdemir, 2015: 134). TOPSIS is known to be an efficient method and can be easily applied in the solution of multi-criteria decision making problems and it can be used to make comparisons between options (Deng et al., 2000: 963). TOPSIS is one of the multi-criteria decision making methods that is used to define solutions among many alternatives (Olson, 2004: 721). TOPSIS is used in many different fields and solution alternatives are created considering the shortest way to the positive-ideal solution and the longest way to the negative-ideal solution (Ömürbek et al., 2013: 124; Supçiller and Çapraz, 2011: 9). Steps of TOPSIS method are described below (Özdemir, 2015: 134-138; Timör and Mimarbaşı, 2013: 23-25).

Step 1: Creating the Decision Matrix (A)
Decision matrix that is created by decision maker is amxp dimensional matrix. In rows, there are decision points that is ranked in superiority and in columns, there are evaluation factors that are used in decision making process. Decision matrix is shown as below:

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & ... & a_{1n} \\ a_{21} & a_{22} & ... & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{m1} & a_{m2} & ... & a_{mn} \end{bmatrix}$$

In the A_{ij} matrix, m represents the number of decision points, n represents the number of evaluation factors.

Step 2: Creating the Standard Decision Matrix (R)
Standard Decision Matrix is calculated by making use of elements from A matrix and using the formula below.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

R matrix is obtained as below:

$$R_{ij} = \begin{bmatrix} r_{11} & r_{12} & ... & r_{1n} \\ r_{21} & r_{22} & ... & r_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ r_{m1} & r_{m2} & ... & r_{mn} \end{bmatrix}$$

Step 3: Creating the Weighted Standard Decision Matrix (V)

First, weight values (w_i) related to evaluation factors are determined $\left(\sum_{i=1}^{n} w_i = 1 \right)$. Then, by multiplying the

elements in each row of R matrix with respective w_i values, V matrix is created. V matrix is shown below:

$$V_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & ... & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & ... & w_n r_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ w_1 r_{m1} & w_2 r_{m2} & ... & w_n r_{mn} \end{bmatrix}$$

Step 4: Creating Ideal (A^*) and Negative Ideal (A^-) Solutions

TOPSIS methods assume that each evaluation factor has a monotonous increasing or decreasing trend.

In order to create ideal solution set, the biggest values (or the smallest values if the evaluation factor is minimization oriented) of weighted evaluation factors of each column in V matrix are selected. Calculating the ideal solution set is shown in the formula below.

$$A^* = \left\{ (\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J') \right\}$$

The set that is calculated with (2.8) formula can be shown as $A^* = \left\{ v_1^*, v_2^*, ..., v_n^* \right\}$.

The negative ideal solution set is created by selecting the smallest values (or the biggest values if the evaluation factor is maximization oriented) of weighted evaluation factors of each column in V matrix. Calculating the negative ideal solution set is shown in the formula below.

$$A^- = \left\{ (\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J') \right\}$$

The set that is calculated with (2.9) formula can be shown as $A^- = \left\{ v_1^-, v_2^-, ..., v_n^- \right\}$.

In both formulas, J represents benefit (maximization) value and J' represents loss (minimization) value.

Both ideal and negative ideal solutions sets are consisted of m number of elements which is the number of evaluation factors.

Step 5: Calculating the Separation Measures

In TOPSIS method, in order to calculate the deviance of each evaluation factor related to a decision point from ideal and negative ideal solution sets, Euclidian Distance Approach is employed. Deviance values of decision points gathered from the calculation are name Ideal Separation Measure (S_i^*) and Negative Ideal Separation Measure (S_i^-). Calculation of Ideal Separation Measure (S_i^*) is shown in (2.10) formula and calculation of Negative Ideal Separation Measure (S_i^-) is shown in (2.11) formula.

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2} \qquad (2.10)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \qquad (2.11)$$

Calculated numbers that are S_i^* and S_i^- will be naturally equal to the number of decision points.

Step 6: Calculating the Relative Closeness to Ideal Solution

Ideal separation measure and negative ideal separation measure are used in calculating the relative closeness (C_i^*) of each decision point to ideal solution. The measure used here is the ratio of negative ideal separation measure in total separation measure. Calculation of relative closeness values to ideal solution is shown in the formula below.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}$$

Here; the C_i^* value obtain values between $0 \le C_i^* \le 1$, $C_i^* = 1$ shows absolute closeness of the decision point to ideal solution and $C_i^* = 0$ shows absolute closeness of the decision point to negative ideal solution.

MOORA Method

MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) method can be expressed as multi-criteria or multi-attribute. It is a process that simultaneously optimizes two or more convergent attributes or objectives with certain constraints (Özdağoğlu, 2014: 283). It is a popular and efficient approach that is used to choose the most suitable and acceptable alternative among available alternatives according to the present conditions. A lot of professional and scientific studies in which this method is applied have been published (Stanujkic et al., 2014: 74). MOORA is a method that was proposed by Brauers and Zavadskas (2006). Even though it is a newly introduced method, it is used in many fields for solving various problems (Stanujkic et al., 2012: 146).Among multi-criteria decision making methods, MOORA is an efficient method for making the right selection among alternatives despite requiring less time and operation for calculation process (Özçelik and Atmaca, 2014:2).

There are several MOORA method in the literature. MOORA-Ratio method, MOORA-Reference point approach, MOORA-Significance Coefficient, MOORA-Full Multiplicative Form and MULTI-MOORA are different versions of the MOORA. However, in some studies, MOORA method is mostly applied in two categories: ratio method and reference point approach (Yıldırım and Önay, 2013: 68). In the conducted analyses, some studies use both of the methods and some studies perform ranking by using only one of them (Önay, 2015: 246). Multi-objective optimization based on the ratio analysis is known to be an analysis with multi-criteria or multi-attributes (Attri and Grover, 2014: 320).

Steps of the MOORA-Ratio Method are explained below.
In the Ratio Method, normalization process is realized by dividing criteria by the square root of the total of every squared alternatives in which $i = 1,2,3,...m$ is the number of alternatives and $j = 1,2,3,...n$ is the number of criteria. This process is realized by the formula below;

$$x_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

In the table created after the normalization process, criteria are determined whether they are maximum or minimum and summed up, then the total value of the minimum criteria is subtracted from the total value of maximum criteria (Yıldırım and Önay, 2013: 247).

$$Y_i = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^*$$

Y_i; is the normalized evaluation of the "i alternative" according to all criteria. The process is completed by ordering Y_i

3. Analysis and Findings

The purpose of this study is to determine the criteria that are effective in laptop selection. To this end, criteria effecting the laptop selection are analyzed by TOPSIS and MOORA methods, then the results are evaluated.

To serve the purpose, six of the criteria that are effective in laptop selection (speed, brand, capacity, display, peripheral equipment and other features, price) are taken from the study conducted by Pekkaya and Altogan (2014). The sample size required for the purpose is determined by the formula below (Kecek and Gürdal, 2016: 30).

$$n = \frac{Nx^2 pq}{d^2(N-1) + x^2 pq}$$

There a total of 196 students in both morning and evening education cycles of the Department of Insurance and Risk Management. The sample size is calculated using the formula above. To determine the best alternative among others, data is gathered from 130 students.

3.1. Using TOPSIS Method in Laptop Selection

Laptop preferences of the students who took part in the study are analyzed by using the Microsoft Office Excel 2013 software according to the TOPSIS method.

Step 1: *Creating the Decision Matrix*

In the TOPSIS method, a decision matrix including the criteria and the alternatives should be created first. While creating the decision matrix, students are asked to evaluate each laptop for each criteria. In this evaluation; 1: Very bad, 2: Bad, 3: Medium, 4: Good, and 5: Very good. Geometric mean of the evaluation results of 130 students who took part in the study is calculated and decision matrix is created with the values shown in Table 2. In the table; C1-C6 represents criteria and L1-L11 represents laptops.

Table 2:Decision Matrix

Alternatives	C1	C2	C3	C4	C5	C6
L1	3,20180	3,28370	3,64910	2,88210	3,09020	3,06110
L2	3,00790	3,28810	3,63000	3,17500	3,32840	3,58330
L3	2,95610	3,15020	2,88340	2,96240	3,15450	3,38690
L4	3,88730	4,02050	3,86380	3,92010	3,80510	3,51310
L5	4,18750	4,61170	4,26860	4,65250	4,28780	3,19100
L6	2,40420	2,69500	2,79550	2,57220	2,36870	2,96400
L7	4,23120	4,05200	4,15970	3,93560	3,98900	3,18920
L8	2,88960	3,15580	3,26770	2,63450	2,69500	2,70930
L9	3,07700	3,25230	3,51930	3,10790	2,92890	2,71510
L10	2,58900	2,22840	2,70660	2,29350	2,43030	2,36970
L11	2,77970	3,09460	2,68920	2,73760	2,54980	2,51790

Step 2: *Normalizing the Decision Matrix*

In this step, criteria values for each alternative in the decision matrix are squared, then values in each column are summed up and square roots of the totals are calculated. As a result, obtained values are shown in Normalized Matrix in Table 3.

Table 3: Normalized Matrix

Alternatives	C1	C2	C3	C4	C5	C6
L1	0,29650	0,29057	0,31919	0,26802	0,29043	0,30335
L2	0,27854	0,29096	0,31752	0,29526	0,31281	0,35510
L3	0,27374	0,27876	0,25222	0,27549	0,29647	0,33563
L4	0,35997	0,35577	0,33797	0,36455	0,35761	0,34814
L5	0,38777	0,40808	0,37338	0,43265	0,40298	0,31622
L6	0,22264	0,23848	0,24453	0,23920	0,22262	0,29373
L7	0,39182	0,35855	0,36386	0,36599	0,37490	0,31604
L8	0,26758	0,27925	0,28583	0,24499	0,25328	0,26849
L9	0,28494	0,28779	0,30784	0,28902	0,27527	0,26906
L10	0,23975	0,19719	0,23675	0,21328	0,22841	0,23483
L11	0,25741	0,27384	0,23523	0,25458	0,23964	0,24952

Step 3: *Creating Weighted Normalized Decision Matrix*

In order to create weighted standard decision matrix, weighted values of evaluation criteria (W_i) should be calculated first. The total of weighted values of the criteria is equal to 1.

Table 4: Weighed Normalized Decision Matrix

WEIGHT	0,04913	0,03245	0,07523	0,10022	0,10022	0,07946
Alternatives	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
L1	0,01457	0,00943	0,02401	0,02686	0,02911	0,02410
L2	0,01368	0,00944	0,02389	0,02959	0,03135	0,02822
L3	0,01345	0,00905	0,01897	0,02761	0,02971	0,02667
L4	0,01769	0,01154	0,02543	0,03653	0,03584	0,02766
L5	0,01905	0,01324	0,02809	0,04336	0,04039	0,02513
L6	0,01094	0,00774	0,01840	0,02397	0,02231	0,02334
L7	0,01925	0,01164	0,02737	0,03668	0,03757	0,02511
L8	0,01315	0,00906	0,02150	0,02455	0,02538	0,02133
L9	0,01400	0,00934	0,02316	0,02897	0,02759	0,02138
L10	0,01178	0,00640	0,01781	0,02138	0,02289	0,01866
L11	0,01265	0,00889	0,01770	0,02551	0,02402	0,01983

Step 4: *Obtaining Ideal and Negative Ideal Solution Values*
In the columns of each criterion in the weighted normalized decision matrix, maximum values are determined as ideal (positive) solution values and minimum values are determined as negative ideal solution values. Ideal and negative ideal solution values for each criterion are shown in Table 5.

Table 5: Ideal and Negative Ideal Solution Values

	C1	C2	C3	C4	C5	C6
I.S.V.	0,01925	0,01324	0,02543	0,03668	0,03757	0,02511
N.I. S.V.	0,01457	0,00943	0,02809	0,04336	0,02911	0,02410

Step 5: *Calculation Ideal and Negative Ideal Separation Measures*
Obtained ideal and negative ideal solution values are subtracted from the weighted normalize ideal values of each criteria and the square roots of the results are calculated to get the distance values ideal and negative ideal solutions. Distance values to ideal solution are shown in Table 6 and distance values to negative ideal solution are shown in Table 7.

Table 6: Distance Values to Ideal Solution

	C1	C2	C3	C4	C5	C6	TOTAL	S*IDEAL
L1	0,00002	0,00001	0,00000	0,00010	0,00007	0,00000	0,00021	0,01441
L2	0,00003	0,00001	0,00000	0,00005	0,00004	0,00001	0,00015	0,01210
L3	0,00003	0,00002	0,00004	0,00008	0,00006	0,00000	0,00024	0,01547
L4	0,00000	0,00000	0,00000	0,00000	0,00000	0,00001	0,00001	0,00385
L5	0,00000	0,00000	0,00001	0,00004	0,00001	0,00000	0,00006	0,00773
L6	0,00007	0,00003	0,00005	0,00016	0,00023	0,00000	0,00055	0,02337
L7	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00001	0,00252
L8	0,00004	0,00002	0,00002	0,00015	0,00015	0,00001	0,00038	0,01949
L9	0,00003	0,00002	0,00001	0,00006	0,00010	0,00001	0,00022	0,01487
L10	0,00006	0,00005	0,00006	0,00023	0,00022	0,00004	0,00065	0,02554
L11	0,00004	0,00002	0,00006	0,00012	0,00018	0,00003	0,00046	0,02142

Table 7: Distance Values to Negative Ideal Solution

	C1	C2	C3	C4	C5	C6	TOTAL	S*NEGATIF IDEAL
L1	0,00000	0,00000	0,00002	0,00027	0,00000	0,00000	0,00029	0,01700
L2	0,00000	0,00000	0,00002	0,00019	0,00001	0,00002	0,00023	0,01517
L3	0,00000	0,00000	0,00008	0,00025	0,00000	0,00001	0,00034	0,01843
L4	0,00001	0,00000	0,00001	0,00005	0,00005	0,00001	0,00013	0,01122
L5	0,00002	0,00001	0,00000	0,00000	0,00013	0,00000	0,00016	0,01276
L6	0,00001	0,00000	0,00009	0,00038	0,00005	0,00000	0,00053	0,02308
L7	0,00002	0,00000	0,00000	0,00004	0,00007	0,00000	0,00014	0,01203
L8	0,00000	0,00000	0,00004	0,00035	0,00001	0,00001	0,00042	0,02051
L9	0,00000	0,00000	0,00002	0,00021	0,00000	0,00001	0,00024	0,01554
L10	0,00001	0,00001	0,00011	0,00048	0,00004	0,00003	0,00067	0,02597
L11	0,00000	0,00000	0,00011	0,00032	0,00003	0,00002	0,00047	0,02179

Step 6: *Calculating the Relative Closeness to Ideal Solution*

This step is the final step of TOPSIS method and obtained values of alternatives help to determine the priority of each alternative. It is calculated by dividing distance values to negative ideal of the alternative by the total of distance values to alternative itself and to positive (ideal) solution. Values for ideal solution are presented in Table 8.

Table 8: Values for Ideal Solution

Alternatives	S*IDEAL	S*N. IDEAL	C_i
L1	0,03898	0,00389	0,09077
L2	0,01584	0,03004	0,65479
L3	0,02009	0,02184	0,52085
L4	0,00975	0,03344	0,77433
L5	0,02444	0,01908	0,43852
L6	0,01848	0,02268	0,55105
L7	0,00086	0,03980	0,97880
L8	0,02321	0,01744	0,42909
L9	0,01838	0,02234	0,54861
L10	0,01294	0,03162	0,70953
L11	0,01782	0,02276	0,56095

As can be seen in Table 8, laptop brands which are analyzed in this study using the TOPSIS method are ranked in the following order; Toshiba (L7), Lenovo (L4), Packard Bell (L10), Asus (L2), Dell (L11), Casper (L6), MSI (L9), Acer (L3), Apple (L5), Exper (L8), and HP (L1).

3.2. Using MOORA Method in Laptop Selection

Laptop preference of the students taken part in the study are also investigated by MOORA method and the results are compared with the results of the TOPSIS method. Creating decision matrix in Table 4 and creating normalized decision matrix shown in Table 4 with MOORA method are the same procedures as in TOPSIS method. Thus, these operations are not presented again.

In the solution of ratio system approach; criteria in the table obtained as a result of the normalization process are determined as maximum or minimum and summed up, then minimum criteria values are subtracted from the total maximum criteria values. In Table 9, Yi values are calculated with the formula and the alternatives are ranked. In the final result, the most suitable alternative is determined with the obtained values and these values are shown in Table 10.

Table 9: The results and the ranking of the alternatives according to the ratio system

Alternatives	MAX	MIN	Difference	Rank
L1	0,10398	0,0241	0,07988	5
L2	0,10795	0,02822	0,07973	6
L3	0,09879	0,02667	0,07212	8
L4	0,12703	0,02766	0,09937	3
L5	0,14413	0,02513	0,11900	1
L6	0,08336	0,02334	0,06002	11
L7	0,13251	0,02511	0,10740	2
L8	0,09364	0,02133	0,07231	7
L9	0,10306	0,02138	0,08168	4
L10	0,09023	0,01866	0,07157	9
L11	0,08877	0,01983	0,06894	10

The differences are calculated according to the MOORA ratio method and the alternatives are arranged. As a result of the ranking, laptop brands are ranked in the following order; L5, L7, L4, L9, L1, L2, L8, L3, L10, L11, L6.

Table 10: Laptop selection ranking according to the multi-criteria decision making methods: TOPSIS and MOORA

Alternatives	TOPSIS	MOORA
L1	11	5
L2	4	6
L3	8	8
L4	2	3
L5	9	1
L6	6	11
L7	1	2
L8	10	7
L9	7	4
L10	3	9
L11	5	10

In Table 10, different ranking of the multi-criteria decision making methods TOPSIS and MOORA are presented. According to the TOPSIS method, L7 is in the first rank and L1 is the last rank while according to the MOORA method, L5 is the first rank and L6 is the last rank.

4. Conclusion and Evaluation

In multi-criteria decision making problems, making the right selection between alternative is an important factor. Selecting a product that is suitable for the needs changing continuously and rapidly with the developments in the technology is quite important. While selecting a laptop which is one of the requirements of the daily life in the present, several criteria and alternatives should be taken into consideration. In this study, in a laptop selection problem with six criteria that are effective in laptop selection among eleven brands, multi-criteria decision making methods TOPSIS and MOORA are used together. In accordance with the findings of the study, Toshiba brand is found to be the best brand according to the evaluation based on the criteria with TOPSIS method; and Apple brand is found to be the best brand according to the evaluation based on the criteria with MOORA method. However, it should be considered that the results can change if different criteria are used. New evaluations for laptop selection can be conducted considering the changes in laptop specifications, which are used in the study, along with the future advancements in the technology.

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