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Laptop selection with MEREC based WASPAS method

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Abstract

With the development of technology, computers have become very important in both daily life and business life. Evaluation of many data together, error-free and fast calculation has been facilitated by computers. With the development of remote working and field work areas, laptop computers have become more preferred for companies. Today, there are many different brands of laptop. The presence of many criteria and alternatives makes selection difficult for decision makers. In this case, the use of multi-criteria decision making (MCDM) methods makes it easier for the decision maker to make the most beneficial choice. With MCDM methods, it is possible to select, sort and classify options with different features in the decision-making process. In this study, while making the most appropriate selection, priorities were determined with the MEREC (Method based on the Removal Effects of Criteria) method, which is one of the objective weighting methods, and the alternatives were listed with the WASPAS (Weighted Aggregated Sum Product Assessment) method. As a result of the processes, the most important criterion was the battery life, which corresponds to the K7 among the seven criteria, while the best alternative among the seven alternatives was A2.

Keywords: MCDM, MEREC, WASPAS, Laptop selection

JEL Codes: C30, D81

1. Introduction

With the development of technology, the use of computers has gained importance both in daily life and in corporate life. Computers are used for data entry and storage, creating tables and graphics, making calculations with less error rate, and many other evaluations. Laptop computers have become indispensable for companies today, as remote working and field work areas are developing. Today, the presence of laptop belonging to many brands can lead to confusion by buyers. It is possible for users to use multi-criteria decision making (MCDM) methods in their selections so that they can get the most efficient product according to their needs.

Thanks to MCDM, many quantitative and qualitative criteria are determined in a decision process, and it becomes possible to select, rank or classify one or more of the alternatives with different characteristics according to different weighted criteria (Özbek, 2019: 25). Since MCDM methods have a structure that can solve simultaneously by bringing together many criteria and alternatives, it makes it easier to make the right decision in solving complex problems encountered in practice (Arıcan, 2019: 15). MCDM offers different ways of calculating options and weight values (Ertuğrul & Budak, 2019:66).

Users want to choose the most useful alternative. Reaching a solution in a problem with different alternatives and criteria can become complicated. In such cases, it is possible to use MCDM methods. Today, with the development of technology, many brands have laptop options with different features. In this study, it is aimed to select laptop for a business with the integrated use of MEREC (Method based on the Removal Effects of Criteria) and WASPAS (Weighted Aggregated Sum Product Assessment) methods. Objective criteria weights were determined with the MEREC method and alternatives were

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listed with the WASPAS method. The MEREC method was preferred because it is a new method in the literature, the process steps are far from glare, and it is an objective method. The WASPAS method is not a very new method in the literature, but it was preferred when it consists of a combination of the weighted sum model and the weighted product model, and also provides consistency control in the ranking of alternatives by performing sensitivity analysis within its own processing steps. In the study, seven alternatives and seven criteria were determined for the selection of laptop. While determining the criteria, it was presented to the purchasing department by making use of previous studies in the literature. Alternatives were determined from the preferred brands in the sector.

In the introduction part of this study, the aim of the study and information about the subject are given. In the first chapter, information about the MEREC and WASPAS methods to be used in the application and the process steps are explained. In the second part, the literature review related to the subject discussed in the study is mentioned. In the next part of the study, the selection of laptop for a business is discussed. In the conclusion part, evaluation and suggestions are presented.

2. Literature Review

When the literature is examined, laptop computers are selected by using different MCDM methods and different criteria. Ertuğrul and Karakaşoğlu (2010), selected a computer for a business by using ELECTRE and BAHP methods. They determined 8 criteria for evaluation, including processor speed, video card, system memory, hard disk capacity, battery life, weight, brand reliability and price. Pekkaya and Akdoğan (2014), evaluated the results by using different MCDM methods together in their study. In the study, they determined speed, brand, capacity, image, peripheral equipment and price criteria. Lakshmi et al. (2015), discussed the alternatives with the TOPSIS method under 10 criteria, including cost, features, warranty, size, battery life, weight, wi-fi, operating system, keyboard and touchpad. Adalı and Işık (2017), evaluated the alternatives under 9 criteria, including processor speed, cache, video card memory, memory, screen resolution, screen size, brand reliability, weight and cost, in laptop selection using MULTIMOORA and MOOSRA methods. Aytekin and Kuvat (2018), evaluated using the AHP method. Babacan (2018), integrated AHP and TOPSIS methods for laptop selection and based on RAM, HDD, video card, screen size, processor and cost criteria. Ulutaş and Cengiz (2018), determined 11 criteria including design, processor speed, cache, video card memory, RAM, screen resolution, hard disk, weight and cost, and they preferred the EVAMIX method to rank the alternatives while using the CRITIC method to determine the criteria weights.

In this study, the MEREC method used to determine the criterion weights for laptop selection was developed by Ghorabaee et al. (2021), distribution location selection of a business located in Iran (Ghorabaee, 2021), evaluation of the performance of a logistics company by years (Toslak et al., 2022), pallet truck selection (Ulutaş et al., 2022), hospital location selection. (Hadi & Abdullah, 2022) and the evaluation of countries according to the social development index (Ayçin and Arsu, 2022), sustainable and indomitable supplier selection (Karakaş, 2022) were used in decision problems. In the continuation of the study, the WASPAS method used in ranking the alternatives was used by Chakraborty et al. (2015), server selection (Yurdoğlu & Kundakcı, 2017), supplier selection (Adalı & Işık, 2017), evaluation of logistics performances of OECD countries (Çelik, 2020), supplier selection (Tayalı, 2017), ranking of provinces in Turkey according to livability criteria (Özbek, 2019), evaluation of third party logistics providers (Pamucar et al., 2019), facade cladding selection for public buildings (Zavadskas et al., 2013) and shopping center location selection (Hashemkhani Zolfani et al., 2013) used in the decision problem.

3. Methods to be used in the Study

In this study, firstly, the MEREC method, which will be used to determine the criterion weights, is explained, and then the WASPAS method, which will provide the ranking of the alternatives, is included.

3.1. MEREC Method

The MEREC method is an objective criterion weighting method introduced to the literature by Ghorabaee et al. in 2021 (Ghorabaee et al., 2021). Different from the other objective criterion weighting methods, Entropy, CILOS, IDOCRIW and CRITIC methods, the MEREC method disables the total value while calculating the importance weight of a criterion. focuses on the change in criterion weight. The processing steps of the MEREC method are shown below (Ghorabaee et al., 2021).

Step 1. Defining the decision matrix

$$X=\begin{bmatrix} x_{12} & x_{12} & \cdots & x_{1j} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{im} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nj} & \cdots & x_{nm} \end{bmatrix} \quad i= 1, 2, \ldots, m \text{ ve } j= 1, 2, \ldots, n. \tag{1}$$

The decision matrix elements shown in Equation (1) must be a positive value. In case of negative values, they should be made positive using appropriate methods.

Step 2. Normalizing the decision matrix

The decision matrix is normalized with the help of the following equations. Equation (2) normalizes the benefit criteria, Equation (3) normalizes the cost criteria.

$$n_{ij}^{x}=\begin{cases} \dfrac{\min_k x_{kj}}{x_{ij}} \; if \; j \in \beta & (2) \\ \dfrac{x_{ij}}{\max_k x_{kj}} \; if \; j \in \mathcal{H} & (3) \end{cases}$$

Step 3. Calculation of the total performance value of alternatives (Si)

Values are obtained with the help of equation (4).

$$S_i = \ln\left(1+\left(\frac{1}{m}\sum\left|\ln(n_{ij}^{x})\right|\right)\right) \tag{4}$$

Step 4. Calculation of changes in the performance value of alternatives (S'_{ij})

By subtracting the value of each criterion with equation (5), the changes in the performance value of the alternatives (S'_{ij}) are calculated.

$$S'_{ij} = \ln\left(1+\left(\frac{1}{m}\sum\left|\ln(n_{ik}^{x})\right|\right)\right) \tag{5}$$

Step 5. Calculating the sum of absolute deviations

With the help of equation (6), the sum of absolute deviations (E_j) is calculated. In this step, the effect of subtraction on the criterion itself is measured.

$$E_j = \sum\left|S'_{ij} - S_i\right| \tag{6}$$

Step 6. Determination of criterion weights

With the help of equation (7), criterion weights (w_j) are calculated.

$$w_j = \frac{E_j}{\sum_k E_k} \tag{7}$$

3.2. WASPAS Method

WASPAS method Zavadskas et al. (2012). It is one of the advantages of the method that the calculation steps of the method are short and easy. The steps of the five-step method are shown below (Zavadskas et al., 2012):

Step 1. Defining the decision matrix: The m alternative decision matrix with n criteria is shown in Equation (8).

$$X=[x_{ij}]_{mxn}=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad i=1, 2, \ldots, m \text{ ve } j=1, 2, \ldots, n. \tag{8}$$

Step 2. Normalizing the decision matrix: At this stage, if the criteria are in the direction of maximization, Equation (9) is used, if the criteria are in the direction of minimization, Equation (10) is used.

$$x_{ij}^{*}=\frac{x_{ij}}{\max_{i}(x_{ij})} \qquad i=1, 2, \ldots, m \text{ ve } j=1, 2, \ldots, n. \tag{9}$$

$$x_{ij}^{*}=\frac{\min_{i} x_{ij}}{x_{ij}} \qquad i=1, 2, \ldots, m \text{ ve } j=1, 2, \ldots, n. \tag{10}$$

Step 3. Obtaining the Relative Performance of Alternatives with WSM: Values are obtained with the help of Equation (11).

$$Q_i^{(1)}=\sum_{j=1}^{n} r_{ij} w_j \tag{11}$$

Step 4. Obtaining the Relative Performances of Alternatives with WPM: In this step, WPM values are obtained by Equation (12).

$$Q_i^{(2)}=\prod_{j=1}^{n} r_{ij}^{w_j} \tag{12}$$

Step 5. Obtaining the Final Relative Performance of the Alternatives: The total relative performance values of the alternatives were obtained by Equation (13).

$$Q_i = \lambda Q_i^{(1)} + (1-\lambda) Q_i^{(2)} \tag{13}$$

Here, λ is a parameter that takes a value between 0 and 1 in the WASPAS method. Zavadskas et al. (2012) determined the value of λ as 0.5. In the WASPAS method, the ranking of the alternatives is done according to their Qi values. The best alternative has the highest Qi value.

4. Application

In the study, it is aimed to choose a laptop for a business. In the selection of the laptop to be taken, criteria were determined for the purchasing department by using the literature (Babacan, 2018; Ulutaş and Cengiz, 2018). The determined alternatives consist of the preferred brands in the sector. In the study consisting of 7 criteria and 7 alternatives, the MEREC method, which is one of the objective criteria weighting methods, was used to determine the criterion weights, and the WASPAS method was preferred for ranking the alternatives. While processor speed, cache, RAM, battery life and hard disk capacity were maximization-based criteria, weight and cost were minimization-oriented criteria. Table 1 gives information about the criteria.

Table 1. Criteria and Codes

Criteria Code	Criteria Type	Criteria Name
C1	Maximization	Processor Speed (GHz)
C2	Maximization	Cache (MB)
C3	Maximization	RAM (GB)
C4	Minimization	Weight (Kg)
C5	Minimization	Cost (TL)
C6	Maximization	Battery Life (Hour)
C7	Maximization	Hard Disk Capacity (GB)

4.1. Determination of Criteria with The MEREC Method

The decision matrix was created and shown in Table 2.

Table 2. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
	Processor Speed (GHz)	Cache (MB)	RAM (GB)	Weight (Kg)	Cost (TL)	Battery Life (Hour)	Hard Disk Capacity (GB)
A1	2,4	8	8	1,65	10999	8,5	256
A2	2,4	8	8	1,20	8999	16	512
A3	2,4	8	8	1,60	10499	6	512
A4	2,6	4	4	1,50	8499	10	128
A5	2,4	4	16	1,80	9449	3	256
A6	2,1	4	8	1,85	9449	6	512
A7	1,7	4	4	1,75	6739	6,4	256

C1, C2, C3, C6 and C7 were normalized using Equation (2), C4 and C5 were normalized using Equation (3). The normalized matrix is shown in Table 3.

Table 3. Normalized Matrix

	C1	C2	C3	C4	C5	C6	C7
	Processor Speed (GHz)	Cache (MB)	RAM (GB)	Weight (Kg)	Cost (TL)	Battery Life (Hour)	Hard Disk Capacity (GB)
A1	0,708	0,500	0,500	0,892	1,000	0,353	0,500
A2	0,708	0,500	0,500	0,649	0,818	0,188	0,250
A3	0,708	0,500	0,500	0,865	0,955	0,500	0,250
A4	0,654	1,000	1,000	0,811	0,773	0,300	1,000
A5	0,708	1,000	0,250	0,973	0,859	1,000	0,500
A6	0,810	1,000	0,500	1,000	0,864	0,500	0,250
A7	1,000	1,000	1,000	0,946	0,613	0,469	0,500

Total performance values (S_i) were obtained by using Equation (4) and are shown in Table 4.

Table 4. Total Performance Values (S_i)

	A1	A2	A3	A4	A5	A6	A7
S_i	0,64	0,86	0,69	0,42	0,50	0,58	0,40

Equation (5) was used to calculate the changes in the performance value of the alternatives. S'_{ij} values are shown in Table 5.

Table 5. Changes in Performance Value of Alternatives (S'_{ij})

	C1	C2	C3	C4	C5	C6	C7
A1	0,59	0,54	0,54	0,62	0,64	0,49	0,54
A2	0,82	0,78	0,78	0,81	0,84	0,66	0,70
A3	0,65	0,60	0,60	0,68	0,69	0,60	0,50
A4	0,35	0,42	0,42	0,39	0,38	0,20	0,42
A5	0,45	0,50	0,27	0,50	0,48	0,50	0,39
A6	0,55	0,58	0,48	0,58	0,56	0,48	0,36
A7	0,40	0,40	0,40	0,40	0,32	0,27	0,28

For the last step of the criterion weighting process, criterion weights were determined by using Equation (6). Weight values are given in Table 6.

Table 6. Sum of Absolute Deviations and Criterion Weights

	C1	C2	C3	C4	C5	C6	C7
e_{ij}	0,2838	0,2629	0,6008	0,1290	0,1998	0,8913	0,8952
w_j	0,0870	0,0806	0,1841	0,0395	0,0613	0,2732	0,2744

4.2. Ranking of Alternatives Using the WASPAS Method

The decision matrix, which is the first step of the WASPAS method, was created with the help of Equation (8). The decision matrix is shown in Table 7.

Table 7. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
Weights	**0,0870**	**0,0806**	**0,1841**	**0,0395**	**0,0613**	**0,2732**	**0,2744**
A1	2,4	8	8	1,65	10999	8,5	256
A2	2,4	8	8	1,2	8999	16	512
A3	2,4	8	8	1,6	10499	6	512
A4	2,6	4	4	1,5	8499	10	128
A5	2,4	4	16	1,8	9449	3	256
A6	2,1	4	8	1,85	9449	6	512
A7	1,7	4	4	1,75	6739	6,4	256

Equation (9) and Equation (10) were used to obtain the normalized decision matrix. Values are given in Table 8.

Table 8. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7
Weights	**0,0870**	**0,0806**	**0,1841**	**0,0395**	**0,0613**	**0,2732**	**0,2744**
A1	0,923	1,000	0,500	0,727	0,613	0,531	0,500
A2	0,923	1,000	0,500	1,000	0,749	1,000	1,000
A3	0,923	1,000	0,500	0,750	0,642	0,375	1,000
A4	1,000	0,500	0,250	0,800	0,793	0,625	0,250
A5	0,923	0,500	1,000	0,667	0,713	0,188	0,500
A6	0,808	0,500	0,500	0,649	0,709	0,375	1,000
A7	0,654	0,500	0,250	0,686	1,000	0,400	0,500

The relative performances of the alternatives were first calculated using the weighted sum method. The total relative importance of each alternative was determined as the weighted sum of the criteria values. Equation (11) is used for this calculation. The results are shown in Table 9.

Table 9. Performance of Options by WSM Method

A1	A2	A3	A4	A5	A6	A7
0,602	0,886	0,699	0,493	0,563	0,649	0,478

Using the equation (12), the relative performances of the alternatives were calculated using the weighted multiplication method and are given in Table 10.

Table 10. Performance of Options by WPM Method

A1	A2	A3	A4	A5	A6	A7
0,583	0,859	0,643	0,430	0,474	0,602	0,448

Using equation (13), the final ranking of the alternatives is reached. The total relative performance values of the WSM and WPM methods and the ranking of the alternatives according to these are shown in Table 11.

Table 11. Final Performance and Ranking of Alternatives

A1	A2	A3	A4	A5	A6	A7
0,592	0,872	0,671	0,462	0,518	0,625	0,463
4	1	2	7	5	3	6

The reliability of the result is tested by performing a sensitivity analysis with λ values between 0.0-1.0. Sensitivity analysis results are given in Table 12.

Table 12. Sensitivity Analysis

	0,0	**0,1**	**0,2**	**0,3**	**0,4**	**0,5**	**0,6**	**0,7**	**0,8**	**0,9**	**1,0**
A1	4	4	4	4	4	**4**	4	4	4	4	4
A2	1	1	1	1	1	**1**	1	1	1	1	1
A3	2	2	2	2	2	**2**	2	2	2	2	2
A4	7	7	7	7	7	**7**	7	7	7	7	7
A5	5	5	5	5	5	**5**	5	5	5	5	5
A6	3	3	3	3	3	**3**	3	3	3	3	3
A7	6	6	6	6	6	**6**	6	6	6	6	6

5. Conclusion

With the development of technology, computers have become very important in daily life and business life. With the increase in areas such as remote working and field work in companies, laptop computers have become more preferable for companies.

Today, there are laptop computer options with different features belonging to many brands. This makes the selection more complex for decision makers. In cases where the number of alternatives and criteria increases, using MCDM methods helps the decision maker to make the most beneficial choice. Thanks to the MCDM methods, the weights of the criteria can be calculated, and the alternatives can be listed.

In this study, it is aimed to select a laptop for a business. For this, seven criteria and seven alternatives have been determined. While determining the criteria, it was presented to the purchasing unit of the enterprise by using the literature. Alternatives are selected from the preferred brands in the sector. The MEREC method, which is one of the objective criteria weighting methods, was used to determine the criterion weights in the decision process. This method was preferred because it is a new method in the literature, the process steps are far from complexity, and it is based on a mathematical basis. The WASPAS method, which is used in ordering the alternatives, is a method used in many studies in different fields in the literature. Since the WASPAS method allows for sensitivity analysis in itself, it was preferred considering that the consistency of the results would be high. As a result of the operations performed by integrating the methods, the criterion with the highest value among the criteria was K7 with a value of 0.2744, and it was concluded that the best alternative was A2. Considering the research, the fact that the result is a preferable product in market conditions and that it is accepted within the enterprise shows that the result is consistent. In the rankings of alternatives tested by sensitivity analysis, the fact that the A2 alternative is in the first place in all values also shows that there is consistency.

The fact that there is no study in which two methods are used together and that the MEREC method is not a very common method makes the study unique. In future studies, the study can be compared by making evaluations under different criteria with different MCDM methods.

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ETİK VE BİLİMSEL İLKELER SORUMLULUK BEYANI

Bu çalışmanın tüm hazırlanma süreçlerinde etik kurallara ve bilimsel atıf gösterme ilkelerine riayet edildiğini yazarlar beyan eder. Aksi bir durumun tespiti halinde Business, Economics and Management Research Journal'ın hiçbir sorumluluğu olmayıp, tüm sorumluluk makale yazarlarına aittir.

Bu çalışma etik kurul izni gerektiren çalışma grubunda yer almamaktadır.

ARAŞTIRMACILARIN MAKALEYE KATKI ORANI BEYANI

1. yazar katkı oranı: %60

2. yazar katkı oranı: %40