CHAPTER 6

AN APPLICATION WITH AHP-TOPSIS HYBRID APPROACH IN LAPTOP SELECTION

Alper AYTEKİN[1]
Hakan AYDOĞAN[2]
Fatma AKGÜN[3]

INTRODUCTION

It has become very easy for people to communicate thanks to the rapidly developing computer technologies and the internet since the millennium. The development of computer technology is currently experiencing rapid progress since its creation (Iqbal & Simangunsong, 2020). With the development of portable computers, information can be accessed anywhere that is connected to the network. Due to the Covid-19, which showed up at the end of 2019 and affected the whole planet as of 2020, many people, especially office staff and students, participated in the distance education or working frenzy. Currently, computers are created not only in the form of personal computers, but also in smaller formats called laptops (Iqbal & Simangunsong, 2020). Although the pandemic has lost its effect, remote working and education continues to maintain its effect. In such an environment, the importance of laptop computers has increased more than ever before.

Computers are complex devices in terms of hardware and software by nature. But each laptop offers different features of each type and gives each type a unique look and shape (Abdillah, 2022). There is a big difference between being able to use a computer and having extensive knowledge in this field. For this reason, it turns into a difficult decision-making process for the buyers, which features of a laptop to be purchased as a necessity should be looked at. Laptops continue to become more and more expensive devices as technology advances. Laptop computer selection is a problem in which many criteria are evaluated simultaneously (Aytekin & Kuvat, 2018). That's why choosing a laptop buyer is very important.

[1] Prof. Dr., Bartın University, Faculty of Economics and Administrative Sciences, Department of Management Information System, aytekin@bartin.edu.tr

[2] Res. Assis, Bartın University, Faculty of Economics and Administrative Sciences, Department of Management Information System, haydogan@bartin.edu.tr

[3] Res. Assis, Bartın Universıty, Faculty of Economics and Administrative Sciences, Department of Management Information System, fakgun@bartin.edu.tr

For laptops, the order of features and criteria can be different for different user groups (Aytekin & Kuvat, 2018). In this study, a selection application was made on multi-criteria decision making, taking into account the opinions of 3 computer experts and faculty members of the Management Information Systems Department. Decision makers determined 8 criteria and 8 alternative laptops based on their knowledge and experience. The criteria they set, price, weight, processor, memory speed, RAM, internal memory, screen size and screen resolution. The Analytical Hierarchy Process (AHP) method was used to evaluate among these criteria. Then, by grading the laptops they determined corresponding to these criteria, the alternatives were sorted by the Rank Preference Technique (TOPSIS) method according to the Ideal Solution Similarity.

Scope of this paper, firstly, the laptop selection in the literature and the studies on AHP and TOPSIS methods are mentioned. Then the methods are explained, and the solution steps are shown. The study has better explained the use of the methods by making a numerical application. Finally, the results of the application were evaluated, and explanations and inferences were put forward.

Literature Review

Xiaolan and Jun (2010) stated in their study that laptop computer selection is a multi-criteria decision-making problem. In this study, they made an application using the AHP method to evaluate and rank laptop suppliers.

Pekkaya and Aktogan (2014) mentioned the importance of using laptop computers in their study. They applied sequencing with other decision-making methods in which the AHP-TOPSIS integrated approach was used.

Vorachit and Srichetta (2014) argued in their study that environmental protection is significant issue for the sustainable development of the country. They made an application using the AHP method to determine the hydroelectric power plant project to be established in a region.

Lakshmi, Venkatesan, and Martin (2015) focused on the structure of multi-criteria decision-making problems in their studies. They stated that the TOPSIS method is the most extensively used multi-criteria decision-making problem. In their study, they made the best laptop selection according to the TOPSIS method.

Ömürbek, Makas, and Ömürbek (2015) mentioned decision problems in general in their studies. In their paper, they made an application by using AHP and TOPSIS methods together to select enterprise project management software for a university.

Tunca, Aksoy, Bülbül and Ömürbek (2015) mentioned the importance of accounting package programs on business life. In their study, they made an application by using AHP, TOPSIS and Elekre methods for the selection of the best accounting package program.

Zaidan et al. (2015) mentioned in their study that EMR software package selection is a challenging process. In their study, they selected the EMR software package with the integrated AHP-TOPSIS method.

Karim and Karmaker (2016) stated in their study that machine selection is a considerable issue for the production systems to work flawlessly in the modern world. In this study, machine selection was made using the integrated AHP-TOPSIS method. They weighted the criteria with AHP and ranked the alternatives with TOPSIS.

Tampi, Pangemanan and Tumewu (2016) emphasized the importance of laptop computers in daily life in their studies. In this study, they chose the best laptop computer according to the scores of the participants using the AHP method.

Kundakçı (2017) argued in his paper that the use of tablet computers in educational institutions has positive effects on students. He used the integrated AHP-OCRA method to make the most appropriate selection of tablet computers to be distributed to students in an educational institution.

Tamer and Gür (2017) argued in their study that customers are trying new channels for product order with changing technology. In their study, they made an application that uses AHP and TOPSIS methods in an integrated way for the selection of third-party logistics companies.

Uslu, Kızıloğlu, İşleyen and Kahya (2017) aimed at the determination of the most suitable place for a new primary school to be opened in Ankara. They made an application using AHP and TOPSIS methods together for the selection of the most convenient location at the points determined by geographic information systems.

Aytekin and Kuvat (2018) stated in their paper that it is a significant issue for computer engineering students to work with the right computer. For this reason, they made an application that listed the criteria that students give importance to in choosing a computer according to the AHP method.

Mitra and Goswami (2019) focused on the difficulty of selection problems in their paper. In their study, they proposed an integrated AHP-TOPSIS method to be able to elect the best desktop computer. They concluded their work by demonstrating the method on a numerical application.

Rajak and Shaw (2019) mentioned in their paper that a mobile health application makes people's lives easier and keeps their health under control. In their study, they made an application with AHP and fuzzy TOPSIS methods to evaluate this application.

Goswami, Behera, and Mitra (2020) said in their study that choosing the best laptop for students is a difficult decision. In this study, they selected a laptop computer that students can use by using the AHP method.

In their study, Iqbal and Simangunsong (2020) intended to create a decision support system for consumers to buy laptops. They suggested that the most appropriate method for the decision support system is AHP. Therefore, in their study, they showed the best laptop computer selection with AHP with a numerical example.

Rashid, Iqbal and Li-jun (2020) focused on the safety of an economically important highway between China and Pakistan in their study. They used the AHP method to map the landslide areas that may occur on this highway.

Aytekin, Akgün, and Aydoğan (2021) focused on a decision-making problem on students studying in the MIS department in their study. In this paper, students' mobile phone selection within certain criteria and brands was examined by AHP and fuzzy AHP methods and demonstrated with a numerical example.

Bulak, Kozanoğlu, Aydoğduoğlu, Göçer and Algül (2021) stated in their study that the value given to e-commerce by businesses increases under competitive conditions. In order to measure and evaluate the usability of e-commerce sites, they sorted the data obtained from users through surveys according to multi-criteria decision-making methods. They concluded the study by reaching and comparing results separately according to the AHP and TOPSIS methods.

Çelik and Aydoğan (2021) stated that hotel selection is an important decision-making problem in their paper. In their studies, they collected data from the internet sites and used the TOPSIS method in order to rank among the luxury hotels in the Istanbul Taksim region.

Ersoy (2021) stated in his study that e-commerce has gained importance with the Covid-19 epidemic and is in a sustainable competition. For this reason, he said that e-commerce companies need the right equipment to do their jobs with the best performance. In his study, he made a numerical application by dealing with the problem of choosing the right laptop computer for an e-commerce company with TOPSIS, EDAS and CODAS methods.

Abdillah (2022), in his study, linked the diversity of laptops to the difference in their prices. He argued that this difference caused the laptop to be on the market in various features and designs. For this reason, he mentioned that the selection of laptop computers suitable for the needs of students and society is an important issue. He designed the decision-making problem with the AHP method and demonstrated it through a numerical application.

METHOD

Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a decision-making mechanism that was developed by Saaty in 1977 and 1980 and started to be used in solving multi-criteria decision-making problems (Dinçer & Görener, 2011). The decision support format can solve a complicated problem in a hierarchy. According to Saaty, hierarchy is a view of a complex problem in a multi-level structure, where the first level is the target, then the factor level, then the criteria, then the sub-criteria, and so on (Abdillah, 2022).

This hierarchical structure is shown in Figure 1 below (Saaty, 1980).

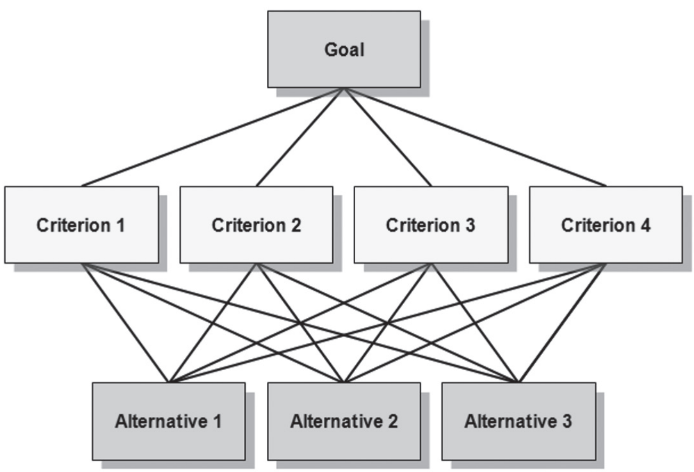

Figure 1: Representation of the AHP Hierarchy

The AHP method is easy to understand and can process both qualitative and quantitative data effectively. AHP does not include heavy math. Due to the advantages, it provides, this method has been used in modeling MCDM problems in many fields with success. It is a tool suitable for use as a structural approach in determining the scores and weights used in the multi-criteria scoring method (Aytekin & Kuvat, 2018). With this method, in decision issues in which many evaluation criteria play a role, criterion weights can be calculated, and the appropriate decision alternative can be selected in order to determine the contribution of the criteria to the goal (Bulak et al., 2021). In this method, the criteria affecting the decision and the comparisons of the alternatives within the scope of these criteria are made by using the 1-9-point preference scale developed by Saaty (Dinçer & Görener, 2011).

The 9-point significance scale used by Saaty for pairwise comparisons and its explanation are shown in Table 1.

Table 1: Saaty's 1-9 point scale and explanation

Explanation	Importance level
Equally Important	1
Moderately Important	3
Quite Important	5
Very important	7
Extremely Important	9
Intermediate Values	2,4,6,8

In AHP, the criteria and alternatives that affect each decision are subjected to pairwise comparisons by the decision-making group, and as a result, the importance weights of the criteria are determined. If a selection is to be made among the alternatives, the relative importance weights of the alternatives are determined as a result of the comparison of the alternatives separately in the light of each criterion, and the alternative with the highest weight is selected. The decision-making group compares the factors with pairwise comparisons and determines how much they contribute to the goal (Dinçer & Görener, 2011).

The method can also be understood as a measurement theory that uses quantitative and/or qualitative data in a broader sense (Kundakçı, 2017). The AHP technique has been used in many areas and is still a method that is up to date today. It can be used alone or in combination with other methods in solving multi-criteria decision-making problems (Dinçer & Görener, 2011).

The steps of the analytical hierarchy process are given below, respectively (Saaty, 1980):

Step 1: A decision matrix is created for each decision maker with the data received from the decision makers (1).

$$Dk = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: The geometric mean is found for each element from the k number of decision matrices obtained (2).

$$X_{ij} = \sqrt[k]{X_{ij}^{(1)} * X_{ij}^{(2)} * \dots * X_{ij}^{(k)}} \quad (2)$$

Step 3: Based on the geometric mean result, the first decision matrix is created (3).

$$D \quad \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix} \quad (3)$$

Step 4: After the matrix D is created, the decision matrix normalized with (4) is created.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{m=1}^{n} x_{mj}^2}} \quad (4)$$

Step 5: The weight values are found by taking the average of each row of the normalized decision matrix (5).

$$X_m = (X_1 + X_2 + \cdots + X_n)/n \quad (5)$$

Step 6: Consistency testing is performed to check the consistency of the weighted values. For the consistency test, firstly, the initial decision matrix and the weight values are multiplied (6) and the result is divided by the weight values (7).

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} * \begin{bmatrix} W_1 \\ \ldots \\ W_m \end{bmatrix} = \begin{matrix} Z_1 \\ \ldots \\ Z_m \end{matrix} \quad (6)$$

$$T_m = Z_m / W_m \quad (7)$$

Step 7: Calculate the λmax value (8). The CI value is calculated (9). RI value is found from the table, RI values are shown in Table 2. The CR value is calculated (10). It is considered consistent if CR < 0.1 (Saaty, 1980).

$$\lambda_{maks} = (Z_1 + Z_2 + \cdots + Z_m)/m \quad (8)$$

$$CI = (\lambda_{maks} - m)/m - 1 \quad (9)$$

$$CR = CI/RI \quad (10)$$

Table 2: RI Values

Table 2: RI Values	RI Value
1	0,00
2	0,00
3	0,52
4	0,89
5	1,11
6	1,25
7	1,35
8	1,40
9	1,45
10	1,49

Technique for Order Preference by Similarity to Ideal Solution TOPSİS

TOPSIS is one of the multi-criteria decision-making methods. In the method, multi-objective decision making problem with 'm' number of alternatives and 'n' number of criteria can be represented by m points in n-dimensional space (Tunca et al., 2015). The TOPSIS method was developed by Hwang and Yoon (1981) and is used in solving multi-criteria decision-making problems (Tamer & Gür, 2017). The TOPSIS (Technique for Order Preference by Smilarity to Ideal Solution) method is based on the assumption that the alternative solution point will be the shortest distance from the positive-ideal solution and the longest distance from the negative-ideal solution (Bulak et al., 2021). The basic principle of the method is that the alternative to be selected by sorting among the alternatives is the closest to the ideal solution and the farthest distance to the negative ideal solution. The solution process is started by establishing a matrix in which the criteria to be listed for superiority are located in the rows and the evaluation factors to be used in decision making are located in the columns (Tamer & Gür, 2017).

The TOPSIS method can be applied directly to the data without a qualitative transformation (Ömürbek et al., 2015). The positive ideal solution is one that tries to maximize the profit criteria and minimize the cost criteria, while the negative ideal solution is the opposite of the previous one. In the TOPSIS method, the exact scores of each alternative from all criteria are used in the creation of the decision matrix and the normalized decision matrix. Considering the ratios of all features, positive and negative ideal solutions are found. By comparing the distance coefficient of each alternative, the order of preference of the alternatives is determined (Karim & Karmaker, 2016).

The steps of the TOPSIS method are given below, respectively (Hwang & Yoon, 1981):

Step 1: With the data taken from the decision makers, the decision matrix for each decision maker is created as in the equation (11).

$$Dk \quad \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{11}$$

Step 2: The geometric mean for each element from the k number of decision matrices obtained is found with the equation numbered (12).

$$X_{ij} = \sqrt[k]{X_{ij}^{(1)} * X_{ij}^{(2)} * \ldots * X_{ij}^{(k)}} \tag{12}$$

Step 3: According to the geometric mean result, the first decision matrix is created as in the equation (13).

$$A = \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix} \quad (13)$$

Step 4: After the matrix A is created, the normalization matrix is created with the equation numbered (14).

$$r_{ij} = \frac{x_{ij}}{\sum_{m=1}^{n} x_{mj}^2} \quad (14)$$

(x_{ij} ; i : 1,2, …, n ; number of criteria j: 1,2, … , m; number of alternatives)

Step 5: The weighted decision matrix is created by multiplying the normalized decision matrix with the weight values as shown in the equation (15).

$$W_{mn} = w_m * N_{mn} \quad (15)$$

Step 6: In the weighted decision matrix, the positive ideal solution and the negative ideal solution are found with the equations (16) and (17).

$$A^+ = \{(maxv_{ij} \mid j \in J), (minv_{ij} \mid j \in J')\} \quad (16)$$

$$A^- = \{(minv_{ij} \mid j \in J), (maxv_{ij} \mid j \in J')\} \quad (17)$$

Step 7: The distance to the positive and negative ideal solutions is found by equation (18) and (19).

$$S_j^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad (18)$$

$$S_j^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (19)$$

Step 8: For each alternative, the relative closeness is calculated with the equation (20) and the alternatives are ranked.

$$C_i^* = \frac{S_j^-}{S_j^- + S_j^+} \qquad 0 \leq C_i^* \leq 1 \tag{20}$$

APPLICATION

Scope, Purpose, and Importance of the Study

This paper is based on the election of a laptop to be used for general purposes. The aim of the study is to examine the selection of the best laptop and/or the alternatives by considering the selected criteria among certain laptop models. Laptop is one of the most used technological tools today. Especially after distance education and remote working conditions, its importance has gradually increased. For this reason, eight criteria and eight alternative laptops were selected by consulting the opinions of academicians from the Management Information Systems (MIS) department to decide on the laptop selection. In order to find a solution to the decision problem, the criteria were evaluated with AHP and the alternatives with TOPSIS, so the integrated AHP-TOPSIS method was applied. Table 3 shows the criteria that YBS academics pay attention to most when buying a laptop.

Table 3: Criteria and Explanations

Criteria	**Explanation**
Price	The price of the laptop to be purchased
Weight	Total weight of the laptop to be purchased
Processor	Processor type of laptop to be purchased
Memory Speed	Processor speed of the laptop to be purchased
RAM	Temporary memory capacity of the laptop to be purchased
Internal Memory	Total storage amount of laptop to be purchased
Screen Size	Screen size of the laptop to be purchased
Screen Resolution	Image quality over pixels of the laptop to be purchased

The alternatives of the study were determined as in Table 4 below, with market research based on the knowledge and experience of the same expert academicians. Table 4 also shows the important features of the alternatives.

Table 4: Alternative Laptops					
Alternatives	Price (₺)*	Processor	RAM	Memory Speed	Internal Memory **
Asus K3500 PC	17.299	İntel Core i5-11. Nesil	16 GB	2400 MHz	1 TB
Lenovo IdeaPad 3	10.559	AMD Ryzen 7	8 GB	2400 MHz	1 TB
Dell Vostro 3510-F8066	13.958	İntel Core i5-11. Nesil	16 GB	2666 MHz	1,5 TB
Acer Nitro AN515-43	15.699	AMD Ryzen 5	8 GB	1333 MHz	1,1 TB
Asus X515JP-EJ2500	14.899	İntel Core i9-10. Nesil	8 GB	3200 MHz	512 GB
HP Pavilion 13-BB0007NT	14.999	İntel Core i7- 11. Nesil	8 GB	3200 MHZ	1 TB
Toshiba Tecra Z50-A-11E	16.608	İntel Core i5-4. Nesil	4 GB	1600 MHz	500 GB
Huawei MateBook D 14	12.099	İntel Core i5-10. Nesil	8 GB	2400 MHz	256 GB

*Selected from laptops sold between 10,000 – 18,000 ₺.
** Includes the sum of HDD and SSD, if any.

Data Collection

In this study, the knowledge of MIS department academics was used as 3 expert decision makers in order to obtain the data. Decision makers first determined eight criteria in the selection of a general purpose laptop and used the pairwise comparison matrix on a scale of 1-9 to rank these criteria in order of importance. Then, they determined eight different laptops in the market and created alternatives. In comparing the alternatives according to the certain criteria, their features were taken from the website of Hepsiburada.com, which is an online sales site. Thus, the scoring of the alternatives against the criteria was done on a scale of 1-10 by asking the academicians.

Evaluation of Research Findings

Step 1: The AHP method is used to compare the criteria in the study. It is defined between 1-8 for easy display of the criteria determined by the decision makers in the tables. C1: Price, C2: Weight, C3: Processor, C4: Memory Speed, C5: RAM, C6: Internal Memory, C7: Screen Size, C8: Screen Resolution. The criteria determined by expert decision makers in the field are evaluated according to Saaty's 1-9 scale. Then, Table 5 is created by taking the geometric mean of the pairwise comparison values to collect the evaluation results and reduce them to a single matrix.

Table 5: Comparison of Criteria								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
C1	1,000	6,214	1,817	3,915	2,621	2,884	4,160	4,000
C2	0,161	1,000	0,151	0,141	0,116	0,144	0,303	0,232
C3	0,550	6,604	1,000	3,684	1,442	3,634	5,769	4,481
C4	0,255	7,114	0,271	1,000	0,322	1,494	2,621	2,000
C5	0,382	8,653	0,693	3,107	1,000	3,420	4,481	3,557
C6	0,347	6,952	0,275	0,669	0,292	1,000	4,642	4,309
C7	0,240	3,302	0,173	0,382	0,223	0,215	1,000	0,693
C8	0,250	4,309	0,223	0,500	0,281	0,232	1,442	1,000

Step 2: A normalized decision matrix is created to evaluate the criteria. Normalized criteria comparisons are shown in Table 6.

Table 6: Normalized Criteria Comparisons								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
C1	0,314	0,141	0,395	0,292	0,416	0,221	0,170	0,197
C2	0,051	0,023	0,033	0,010	0,018	0,011	0,012	0,011
C3	0,173	0,150	0,217	0,275	0,229	0,279	0,236	0,221
C4	0,080	0,161	0,059	0,075	0,051	0,115	0,107	0,099
C5	0,120	0,196	0,151	0,232	0,159	0,263	0,184	0,175
C6	0,109	0,157	0,060	0,050	0,046	0,077	0,190	0,213
C7	0,075	0,075	0,038	0,028	0,035	0,017	0,041	0,034
C8	0,078	0,098	0,048	0,037	0,045	0,018	0,059	0,049

Step 3: The weight values of the criteria are found from the normalized criteria comparisons. The weights of the criteria are shown in Table 7.

Table 7: Weight Values of Criteria								
Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Weights	0,268	0,021	0,222	0,093	0,185	0,113	0,043	0,054

Step 4: After the weighting process, the CR value is found to test the consistency of the model. Since there are eight criteria in this model, the RI value was found from the table and taken as 1.40. The CR value of the model is consistent as 0.066 < 0.1 according to the calculations. The consistency test of the model is shown in Table 8.

Table 8: λ, CI, RI and CR Values

λ	CI	RI	CR
8,647	0,092	1,410	0,066

Step 5: The TOPSIS method is used to evaluate and rank the alternatives. In order to create the decision matrix, the information obtained from expert decision makers and the data of Hepsiburada.com were used. It is defined between 1-8 in order to show the determined alternatives easily in the tables. A1: Asus K3500 PC, A2: Lenovo IdeaPad 3, A3: Dell Vostro 3510-F8066, A4: Acer Nitro AN515-43, A5: Asus X515JP-EJ2500, A6: HP Pavilion 13-BB0007NT, A7: Toshiba Tecra Z50-A -11E, A8: Huawei MateBook D 14. Each decision maker evaluated each alternative for all criteria on a scale of 1-10, and in order to combine these values, Table 9 was created by taking the geometric mean.

Table 9: Decision Matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	3,107	7,268	7,000	4,932	7,958	5,944	4,932	8,320
A2	7,560	7,268	4,642	4,932	4,932	5,944	6,542	6,316
A3	4,579	5,944	7,000	7,319	7,958	8,963	6,542	6,316
A4	3,915	2,884	3,302	1,817	4,932	6,952	6,542	3,175
A5	4,932	7,268	9,655	8,653	4,932	4,932	6,542	6,316
A6	4,932	7,268	8,320	8,653	4,932	5,944	1,817	6,316
A7	2,884	5,944	5,313	3,634	1,817	4,932	6,542	6,316
A8	5,646	5,944	6,000	4,932	4,932	1,817	4,932	6,316

Step 6: Normalized decision matrix is created. After the decision matrix was created, the matrix was normalized with the formula (12) in the method section. The normalized decision matrix is shown in Table 10.

Table 10: Normalized Decision Matrix								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0,224	0,403	0,370	0,288	0,502	0,351	0,356	0,461
A2	0,546	0,403	0,246	0,288	0,311	0,351	0,472	0,350
A3	0,330	0,329	0,370	0,428	0,502	0,529	0,472	0,350
A4	0,283	0,160	0,175	0,106	0,311	0,411	0,472	0,176
A5	0,356	0,403	0,511	0,506	0,311	0,291	0,472	0,350
A6	0,356	0,403	0,440	0,506	0,311	0,351	0,131	0,350
A7	0,208	0,329	0,281	0,212	0,115	0,291	0,472	0,350
A8	0,408	0,329	0,317	0,288	0,311	0,107	0,356	0,350

Step 7: The weighted decision matrix is created using the normalized decision matrix. The weights determined in Table 7 for the criteria are multiplied by each element of the normalized decision matrix in Table 10 to form a weighted decision matrix. The weighted decision matrix is given in Table 11.

Table 11: Weighted Decision Matrix								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0,060	0,009	0,008	0,027	0,093	0,040	0,096	0,010
A2	0,146	0,009	0,005	0,027	0,057	0,040	0,127	0,007
A3	0,089	0,007	0,008	0,040	0,093	0,060	0,127	0,007
A4	0,076	0,003	0,004	0,010	0,057	0,046	0,127	0,004
A5	0,096	0,009	0,011	0,047	0,057	0,033	0,127	0,007
A6	0,096	0,009	0,009	0,047	0,057	0,040	0,035	0,007
A7	0,056	0,007	0,006	0,020	0,021	0,033	0,127	0,007
A8	0,109	0,007	0,007	0,027	0,057	0,012	0,096	0,007

Step 8: Positive ideal (A+) and negative ideal (A-) solutions are generated using weighted decision matrix. Positive ideal solutions represent the best performance values, and negative ideal solutions represent the worst performance results. Positive and negative ideal solutions are shown in Table 12.

Table 12: Positive and Negative Ideal Solutions								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
(A+)	0,146	0,009	0,011	0,047	0,093	0,060	0,127	0,010
(A-)	0,056	0,003	0,004	0,010	0,021	0,012	0,035	0,004

Step 9: The distance of the weighted values from the positive ideal solutions (S+) and the distance from the negative ideal solutions (S-) are calculated. The results are shown in Table 13.

Table 13: Discrimination Measurements		
	S+	**S-**
A1	0,104	0,089
A2	0,050	0,125
A3	0,062	0,120
A4	0,091	0,089
A5	0,070	0,099
A6	0,129	0,074
A7	0,123	0,075
A8	0,089	0,078

Step 10: The closeness to the ideal solution was calculated and sorted according to the formula (18) in the method section. The ranking is shown in Table 14.

Table 14: Laptop Ranking		
Ranking	**Laptop**	**Result (C*)**
1	Lenovo IdeaPad 3	0,715
2	Dell Vostro 3510-F8066	0,661
3	Asus X515JP-EJ2500	0,585
4	Acer Nitro AN515-43	0,494
5	Huawei MateBook D 14	0,467
6	Asus K3500 PC	0,459
7	Toshiba Tecra Z50-A-11E	0,377
8	HP Pavilion 13-BB0007NT	0,366

CONCLUSION

This study aimed to select a laptop to be used for general purposes under certain constraints and criteria and to rank other laptops. Recently, there has been an increasing need for remote work and distance education, especially after the pandemic. For this reason, laptop computers, which are one of the most noteworthy technological tools in accessing the internet and are portable, have become more remarkable than ever. In this period when technology has turned into a necessity and prices have increased, choosing a laptop is a difficult issue for users who do not have knowledge of the subject. For this reason, the solution of the problem is provided by using the Analytical Hierarchy Process (AHP), which is extensively used in the literature, and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) integrated. Selected criteria with AHP were compared in pairs and ranked. With TOPSIS, the alternatives were ranked as a result of the evaluation according to the criteria. It has been shown that more robust results are obtained by using the two methods together.

In this study, three academicians in the MIS department were selected as decision makers. Decision makers agreed on eight criteria for the selection of a laptop to be used for general purposes. These criteria are; price, weight, processor, memory speed, RAM, internal memory, screen size and screen resolution. It was scored using Saaty's 1-9 scale to evaluate the criteria. Then, eight laptops were determined by the decision makers for the alternatives. In order to evaluate the features of the specified laptops, data were obtained from the website Hepsiburada.com in April 2022. Thus, the evaluation of the alternatives against the criteria was made on a scale of 1-10. The weighting and ranking of the criteria made according to the scoring of the decision makers are shown in Figure 2.

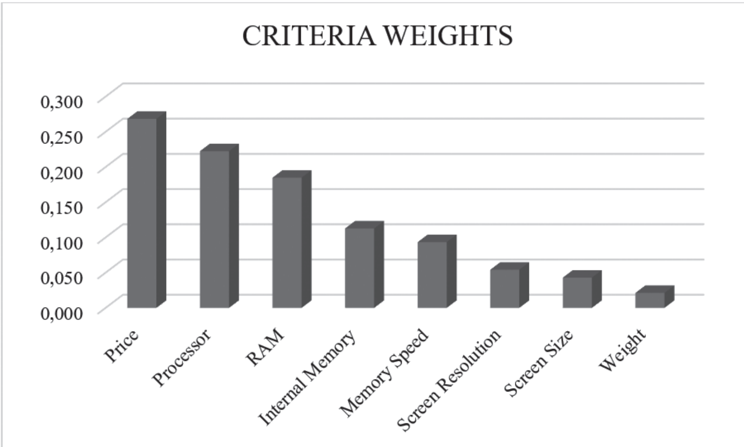

Figure 2: Criteria Weights

As shown in Figure 2, it is seen that the most valued criterion by buyers is price. Processor, RAM, internal memory, memory speed, screen resolution, screen size and weight follow the price criteria in order. The ranking of the alternatives in this study against the weighted criteria above is shown in Figure 3 below.

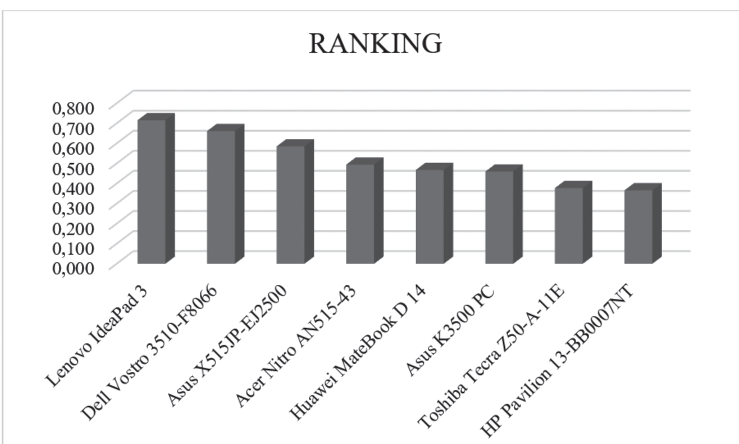

Figure 3: Ranking of Alternatives

As shown in Figure 3, it is seen that Lenovo IdeaPad 3 is the most suitable laptop to choose from among the alternatives. Lenovo IdeaPad 3 is followed by Dell Vostro 3540-F8066, Asus X515JP-EJ2500, Acer Nitro AN515-43, Huawei MateBook D 14, Asus K3500 PC, Toshiba Tecra Z50-A-11E and HP Pavilion 13-B

B0007NT, respectively.

Since the alternatives chosen in this study are chosen in line with the suggestions of the decision makers, the limitation of the application is that it will only be proven correct on the selected models. Therefore, it is obvious that results may change as models change and diversification increases. As a further study, ranking can be done by performing the evaluations of the decision makers in a fuzzy environment. In addition, the differences can be revealed and discussed by comparing the two studies.

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