AN APPROACH FOR LAPTOP COMPUTERS EVALUATION USING MULTIPLE-CRITERIA DECISION ANALYSIS

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Abstract

Computer hardware can have a very significant impact on the overall performance of an information system. Choosing hardware with adequate characteristics without increasing costs is an important and challenging decision-making problem. This problem is especially evident when selecting computers and laptops, where a greater number of evaluation criteria should be considered. Therefore, in this paper, a multiple criteria decision-making approach for the laptop evaluation, based on PIPRECIA and EDAS methods, is considered. In the proposed approach, the PIPRECIA method was used to determine the significance of the criteria and the EDAS method is used for the final ranking of the alternatives. The usability of the proposed model is demonstrated in the case of selection of laptops for teaching staff.

Keywords: computer hardware, laptop, MCDM, PIPRECIA, EDAS.

INTRODUCTION

Multiple Criteria Decision Making (MCDM) is often defined as the process of selecting the most appropriate alternative based on a set of often conflicting criteria. MCDM is a field of Operational Research that is very rapidly developing, and as a result of that a number of MCDM methods have been proposed, which have been used so far to solve many different decision-making problems in different areas.

However, based on the number of articles published in scientific journals and conferences, the impression is that the MCDM is not sufficiently utilized in order to carry out the computer hardware evaluation.

In [1] and [2] is mentioned that some of the rare examples where MCDM methods were used to evaluate computer hardware. Authors in [3] and [4] proposed the evaluation of laptops computers based on the use of MCDM methods. In which articles the evaluation of the laptop is considered using the MCDM method.

Modern computers, especially laptops, have many characteristics that should be considered when choosing a computer for specific purposes. It is also known that better performance has more expensive hardware, which makes the choice of an adequate laptop a much more complex decision-making problem.

Therefore, an approach for laptops evaluation based on the use of MCDM methods is considered in this paper. In the rest of this paper, two MCDM methods are presented in detail, in order to use one of them to determine the weight of the criteria, and the other to evaluate the alternatives. In the next section, a set of evaluation criteria is presented, after which the usefulness of the proposed approach is demonstrated in one case of laptop selection. Finally, the conclusions are given.

MULTIPLE CRITERIA DECISION MAKING

The different phases can be identified in the MCDM process, but only the ones that are

necessary to consider the proposed approach are listed below, such as:

- identification of the evaluation criteria
- determining the significance of the criteria, and
- evaluating and ranking the alternatives in relation to the selected set of criteria.

In this approach the PIPRECIA method is used for determining the significance of criteria, and the EDAS method is used for final ranking of alternatives and selection of the most appropriate one.

THE PIPRECIA METHOD

The PIvot Pairwise RElative Criteria Importance Assessment (PIPRECIA) method [5] is intended to determine the significance of the evaluation criteria, and it was formed as an extension of the SRAWA method [6].

The computational procedure of the PIPRECIA method can be presented as follows [5]:

***Step* 1**. Starting from the second criterion from an unsorted list of criteria, determine the relative importance s_j of criterion j as follows:

$$s_j = \begin{cases} >1 & when\ C_j \succ C_{j-1} \\ 1 & when\ C_j = C_{j-1} \\ <1 & when\ C_j \prec C_{j-1} \end{cases}. \quad (1)$$

***Step* 2**. Determine the coefficient k_j of criterion j as follows:

$$k_j = \begin{cases} 1 & j=1 \\ 2-s_j & j>1 \end{cases}. \quad (2)$$

***Step* 3**. Determine the recalculated weight q_j of criterion j as follows:

$$q_j = \begin{cases} 1 & j=1 \\ \dfrac{q_{j-1}}{k_j} & j>1 \end{cases}. \quad (3)$$

***Step* 4**. Determine the relative weights of the evaluation criteria as follows:

$$w_j = \frac{q_j}{\sum\limits_{k=1}^{n} q_k}. \quad (4)$$

THE EDAS METHOD

The Evaluation based on Distance from Average Solution (EDAS) method is proposed in [7]. The basic ideas of the EDAS method are the use of two distance measures, namely the Positive Distance from Average (PDA) and the Negative Distance from Average (NDA); and that the evaluation of the alternatives is done according to higher values of the PDA and lower values of the NDA. This approach is similar, but not the same, as the approach used in the well-known TOPSIS method.

The computational procedure of the EDAS method can be can be presented as follows [8]:

***Step* 1**. Determine the average solution according to all criteria $x_j^* = (x_1, x_2, \cdots, x_n)$ as follows:

$$x_j^* = \frac{\sum_{i=1}^{m} x_{ij}}{m}, \quad (5)$$

where x_{ij} denotes the performance rating of the alternative i on the criterion j.

***Step* 2**. Calculate the positive distance from average d_{ij}^+ and the negative distance from average d_{ij}^-, according to the type of criteria (benefit and cost), as follows:

$$d_{ij}^+ = \begin{cases} \dfrac{\max(0,(x_{ij}-x_j^*))}{x_j^*}; & j \in \Omega_{\max} \\ \dfrac{\max(0,(x_j^*-x_{ij}))}{x_j^*}; & j \in \Omega_{\min} \end{cases}, \quad (6)$$

$$d_{ij}^- = \begin{cases} \dfrac{\max(0,(x_j^*-x_{ij}))}{x_j^*}; & j \in \Omega_{\max} \\ \dfrac{\max(0,(x_{ij}-x_j^*))}{x_j^*}; & j \in \Omega_{\min} \end{cases}, \quad (7)$$

where $\Omega_{\max}$ and $\Omega_{\min}$ denotes the set of the benefit criteria and the cost criteria, respectively.

Step 3. Determine the weighted sum of PDA, Q_i^+, and the weighted sum of NDS, Q_i^-, for all alternatives, as follows:

$$Q_i^+ = \sum_{j=1}^{n} w_j d_{ij}^+, \qquad (8)$$

$$Q_i^- = \sum_{j=1}^{n} w_j d_{ij}^-. \qquad (9)$$

Step 4. Normalize the values of the weighted sum of the PDA and the weighted sum of the NDA for all alternatives, shown as follows:

$$S_i^+ = \frac{Q_i^+}{\max_i Q_i^+}, \qquad (10)$$

$$S_i^- = 1 - \frac{Q_i^-}{\max_i Q_i^-}, \qquad (11)$$

where S_i^+ and S_i^- denote the normalized weighted sum of the PDA and the NDA, respectively.

Step 5. Calculate the appraisal score S_i for all alternatives, as follows:

$$S_i = \frac{1}{2}(S_i^+ + S_i^-) \qquad (12)$$

Step 6. Rank the alternatives according to the decreasing values of appraisal score. The alternative with the highest S_i is the best choice among the candidate alternatives.

THE EVALUATION CRITERIA

The selection of an adequate set of evaluation criteria is very important in MCDM.

In [4], authors evaluated laptops from nine manufacturers based on the following eight criteria: Specification (RAM, Processor, graphics card, speed), Warranty, Size, Battery life, With or without OS, Weight, Keyboard and Touch pad and Wi-Fi.

Based on the above-mentioned article, as well as consultations with users and IT specialists, the following set of criteria has been selected for evaluation in this approach:
- C_1 - Manufacturer,
- C_2 - Diagonal screen size,
- C_3 - Processor type,
- C_4 - Processor tact,
- C_5 - Cache memory,
- C_6 - RAM,
- C_7 - HDD,
- C_8 - Graphics,
- C_9 - Weight,
- C_{10} - Battery, and
- C_{11} - Price.

The criteria $C_1 - C_3$, C_7, C_8 and C_{10} belong to the set of qualitative criteria and their evaluation is carried out using the Likert's 1–5 scale, while the criteria $C_4 - C_6$, C_9 and C_{11} belong to the set of quantitative criteria and their performance ratings are taken from product specifications.

It should also be noted that the criteria C_9 and C_{10} cost criteria, i.e. the lower performance ratings are more desirable.

In this approach the priority is given to the use of complex evaluation criteria with the aim of forming an efficient and less complex MCDM evaluation model. For example, criterion RAM denotes overall adequacy and quality of RAM memory computer subsystem, and it includes a number of sub-criteria such as: capacity, speed, type, latency and so on. In other words, criterion RAM denotes overall memory adequacy.

In contrast, the use of precisely defined evaluation criteria would lead to the use of a significantly larger number of criteria, which will lead to forming more precise, but also more difficult to use, evaluation model.

Finally, it should be noted that this model is primarily intended for IT specialist.

A NUMERICAL ILLUSTRATION

In order to explain the proposed approach in detail, below is considered an example of the selection of a laptops for teaching staff at the faculty was considered.

After analyzing the supply of laptops on the local market, the next five laptops were identified as acceptable alternatives[1]:

- DELL Inspiron 17 5767
- Lenovo IdeaPad 320-15iap
- ACER Swift SF113-31-P5FG
- HP Pavilion 14-bk007nm
- ASUS X541UA GO1312T

The ratings of alternatives to the qualitative criteria obtained from the two IT specialists involved in the evaluation are shown in Table 1 and Table 2, respectively.

Table 1: *The ratings obtained from the first of the two IT specialist*

	C_1	C_2	C_3	C_7	C_8	C_{10}
A_1	4	4	2	2	3	4
A_2	5	5	2	5	5	3
A_3	1	3	3	4	2	4
A_4	3	3	5	4	3	4
A_5	3	5	5	3	2	4

Table 2: *The ratings obtained from the first of the two IT specialist*

	C_1	C_2	C_3	C_7	C_8	C_{10}
A_1	5	4	2	1	2	4
A_2	3	5	2	5	4	3
A_3	2	2	3	2	1	4
A_4	4	2	4	4	2	4
A_5	4	5	4	3	1	4

The ratings of alternatives to the quantitative criteria are shown in Table 3.

Finally, the initial decision-making matrix is given in Table 4.

Table 3: *The ratings of quantitative criteria*

	C_4	C_5	C_6	C_9	C_{11}
A_1	2.3	2	4	3.09	478.24
A_2	2	3	4	2.2	498.25
A_3	1.1	2	4	1.3	458.25
A_4	2.4	3	4	1.58	499.92
A_5	2	3	4	2	458.33

The responses of the two IT specialist regarding the significance of the evaluation criteria, as well as the weights of the criteria obtained using the PIPRECIA method are shown in Tables 5 and 6.

Table 4: *The initial decision-making matrix*

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
	1-5	1-5	1-5	1-5	MB	GB	1-5	1-5	kg	1-5	Eur
	max	max	max	max	max	max	max	max	min	max	min
A_1	4.5	4	2	2.3	2	4	1.5	2.5	3.09	4	478.24
A_2	4	5	2	2	3	4	5	4.5	2.2	3	498.25
A_3	1.5	2.5	3	1.1	2	4	3	1.5	1.3	4	458.25
A_4	3.5	2.5	4.5	2.4	3	4	4	2.5	1.58	4	499.92
A_5	3.5	5	4.5	2	3	4	3	1.5	2	4	458.33

Table 5: *The responses and weights of the criteria obtained from the first of two IT specialist*

	s_j	k_j	q_j	w_j
C_1		1	1	0.05
C_2	0.80	1.20	0.83	0.04
C_3	1.50	0.50	1.67	0.08
C_4	0.50	1.50	1.11	0.06
C_4	1.20	0.80	1.39	0.07
C_5	1.40	0.60	2.31	0.12
C_6	0.80	1.20	1.93	0.10
C_8	1.30	0.70	2.76	0.14
C_9	0.50	1.50	1.84	0.09
C_{10}	1.10	0.90	2.04	0.10
C_{11}	1.30	0.70	2.92	0.15
	Σ		19.79	1.00

Finally, the group weight criteria, obtained as arithmetic meanings of individual weights, are shown in Table 7.

Table 7: *The group weights of the criteria*

	w_j^1	w_j^2	w_j
C_1	0.05	0.07	0.06
C_2	0.04	0.08	0.06
C_3	0.08	0.11	0.10
C_4	0.06	0.10	0.08
C_4	0.07	0.11	0.09
C_5	0.12	0.10	0.11
C_6	0.10	0.09	0.09
C_8	0.14	0.10	0.12
C_9	0.09	0.08	0.09
C_{10}	0.10	0.08	0.09
C_{11}	0.15	0.09	0.12
	Σ		1.00

Table 6: *The responses and weights of the criteria obtained from the second of two IT specialist*

	s_j	k_j	q_j	w_j
C_1		1	1	0.07
C_2	1.05	0.95	1.05	0.08
C_3	1.30	0.70	1.50	0.11
C_4	0.90	1.10	1.37	0.10
C_4	1.10	0.90	1.52	0.11
C_5	0.90	1.10	1.38	0.10
C_6	0.85	1.15	1.20	0.09
C_8	1.15	0.85	1.41	0.10
C_9	0.80	1.20	1.18	0.08
C_{10}	0.90	1.10	1.07	0.08
C_{11}	1.15	0.85	1.26	0.09
	Σ		13.94	1.00

The weighted and normalized weighted sums of positive and negative distances from the average, obtained by using Eqs. (8) to (11), as well as the appraisal score S_i, calculated by using Eq. (12), are shown in shown in Table 8.

Table 8: *Calculation details obtained using the EDAS method*

	Q_i^+	Q_i^-	S_i^+	S_i^-	S_i	Rank
A_1	0.04	0.15	0.22	0.11	0.16	4
A_2	0.19	0.07	1.00	0.61	0.80	1
A_3	0.04	0.17	0.22	0.00	0.11	5
A_4	0.12	0.03	0.62	0.85	0.73	2
A_5	0.09	0.06	0.46	0.67	0.56	3

As it is shown in Table 8, the best alternative is alternative denoted as A_2.

CONCLUSION

This paper presents an approach for evaluating laptop computers based on the use of two easy-to-use multiple criteria decision-making methods. The experience gained during testing of this approach indicates its usability, but it can also be emphasized that a certain weakness of the proposed model was observed in relation to the proposed set of evaluation criteria. Despite the large number of criteria used in the proposed model, it was also noted that there are also significant criteria that are not included in the proposed model. It has also been noted that a higher efficiency of the proposed model could be achieved by a hierarchical organization of evaluation criteria, which would probably be done if the proposed model continues to develop.

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[1] *Note: The sequence of alternatives in further consideration has been changed to prevent the promotion of a brand of laptops.*