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An Overview of Multiple Criteria Decision Making Techniques in the Selection of Best Laptop Model

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Abstract: This research article presents a detailed study of a laptop selection problem by analyzing through three (Multi-Criteria Decision Making) MCDM techniques namely, (Weighted Sum Model) WSM, (Weighted Product Model) WPM and (Weighted Aggregated Sum Product Assessment Model) WASPAS. The main goal of this study is to propose the best laptop model among a group of seven alternative models based on 10 selection criteria. For this purpose, (Analytic Hierarchy Process) AHP is used to determine the criteria weightages whereas, WSM, WPM, WASPAS techniques are applied individually to determine the best model and to rank the alternatives. The best model is proposed based on the output results of the three MCDM techniques which suggest that alternative 3 and alternative 2 are the optimum and the foulest choice respectively. All the rankings given by the three methodologies are also compared with the previous result which shows that all the three methods are giving the same outcome and the rankings are more or less same with very minor alterations.

Keywords: laptop selection, multi-criteria decision making, analytic hierarchy process, alternative ranking, weighted sum and product model

1. INTRODUCTION

MCDM have become a trending topic for the decision makers to utilized it as a judgmental tool that helps to make proper selection of products or processes. For any sector, it is very important to make right decision at the right time. The primary problem associated in decision making process is the selection criteria that creates confusion among the buyers while purchasing some items like mobile [15, 16, 21], refrigerator, car [42], air-conditioner [1] etc. Let us take an example of a cell phone [21] to explain it clearly, suppose someone wants to buy a cell phone having descent specifications and obviously within the budget, now there are lots of phones available in the market from different brands that create confusion among the buyers which one is the appropriate model to buy and the buyers also have some choices and preferences regarding the phone specifications (i.e. criteria's) like processor, camera, battery capacity, screen size, etc. Ideally, it is not possible that the buyers may get all of their preferable specifications in one model but still they have to select one best model so that most of their requirements can be fulfilled [21]. To get rid from such type of hard situations that arises in our everyday life while taking any decisions, MCDM can guide us to take the right path and provide solution to these types of problems.

Proper selection of laptop model [14, 17, 23, 27, 35, 44] is such type of problem that came under the category of MCDM, since its selection is based on various criteria like screen resolution, RAM, cost, hard disk capacity, brand, color, etc. So, it is quite difficult for the buyers to choose the appropriate laptop model among thousands of available models based on their budget and specifications that perfectly suits their personality. Therefore, MCDM would be the suitable tool for investigating the present problem having various conflicting factors. Although,

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many other techniques like Artificial Neural Network (ANN), Linear Programming Problem (LPP), goal programming etc. are present, but none of the mentioned optimization tools can ever reach the level of MCDM in terms of simplicity and easiness. MCDM techniques are very simple and easy to understand, it requires less computational time, and MCDM necessitates some simple mathematical steps for its operation. On the other hand, alternative optimization process like ANN is quite difficult to grab and full of complex calculations. A detailed analysis of the best laptop model selection is presented in this article from which the buyers can develop some idea about the laptop model while purchasing it. Not only that, but also the laptop manufacturing companies will be benefitted from the present market scenario that helps to reconstruct their future production according to the present market demand.

The ongoing problem is adopted from the paper presented by Adali and Isik [2], where the selection of laptop is carried out by applying Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) [7], Full Multiplicative form of MOORA (MULTIMOORA) [8] and Multi-Objective Optimization on the basis of Simple Ratio Analysis (MOOSRA) [22,26] methods. A panel of five expert members having high market experience of more than 10 years was formed. The panel board members are higher officials and executives who are associated with some of the reputed electronic firms and laptop manufacturing companies. After going through a massive brainstorming session, they [2] considered 10 selection parameters as follows: processor clock speed (PCS) (in Ghz), cache memory (CM) (in Mb), storage space (SS) (in Gb), display card storage (DCS) (in Gb), RAM (R) (in Gb), screen resolution (SR) (in Pixel), screen dimension (SD) (in Inch), brand trustworthiness (BT), weight (W) (in Kg), and price (P) (in Turkish Liars). According to the experts, these are the most important factors for a laptop that a customer usually looked for before purchasing it. The seven laptop models were chosen after studying the present market demand and rigorous research of the past laptop sales history. From the records and statistics of some electronic stores and verbal communication with some of the laptop users, the board members sorted out the seven most suitable laptop models for this analysis. The number of alternative laptop models is restricted to 7 because, with the increasing of alternatives and selection criteria, the order of the decision matrix increases; this makes the calculation portion time-consuming and complicated. The selection process was carried out on the basis of 10 selection parameters and the best model was proposed among the seven chosen alternative models. The criteria weightages were determined by Adali and Isik [2] using AHP [34,38] and the same weightages values are reused in this analysis. The decision makers put their own views and opinions for constructing the AHP pair-wise comparison analysis matrix followed by the criteria weightage's determination which are as follows: W_{C1} = 0.297, W_{C2} = 0.025, W_{C3} = 0.035, W_{C4} = 0.076, W_{C5} = 0.154, W_{C6} = 0.053, W_{C7} = 0.104, W_{C8} = 0.017, W_{C9} = 0.025, W_{C10} = 0.214. Table 4.1 presents the seven chosen alternative laptop models and their respective specifications (criteria's). The screen resolution is measured in 1-3 judgment scale which denotes that: 1 – worst (1366 × 768 pixels), 2 – medium (1600 × 900 pixels), 3 – best (1920 × 1080 pixels) and similarly, brand reliability is also measured in 1-10 judgment scale which denotes that: 1 - worst and 10 - best [2].

A problem similar to the stated above is further extended by implementing three other MCDM techniques, i.e. WSM [11, 30, 33, 45], WPM [32, 45] and WASPAS [48–50] which are discussed in this article. The output results are also compared with the previous results to check whether the outcomes from all the methods are same or not.

2. LITERATURE REVIEW

Many potential researchers have on various MCDM techniques applied in wide variety of areas including industrial sector [9,13,18,19,24], banking and finance sector [25,39], energy sector [20], health and educational sector [6,36], environmental management [37,43], etc.

Afshari et al. [3] applied Simple Average Weighting (SAW or WSM) method to solve the personnel selection problem. Men et al. [31] used Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method to analyze the harmonius society development of east China. Zhang et al. [51] established a technology project credit evaluation index system model, where AHP is used to determine the weights of each evaluation index and the evaluation results was analyzed through Fuzzy Comprehensive Evaluation Method (FCEM). Gong et al. [12] applied Fuzzy Analytic Hierarchy Process (FAHP) for determining the customer requirements in software quality function deployment, and the vitality degree was analyzed using trapezoidal fuzzy function. Wang et al. [47] used ANP and Fuzzy assessment method to assess and rank the risk factor strategies using triangular fuzzy numbers. Zavadskas et al. [50] measured the accuracy of WSM and WPM methods and proposed a joint WASPAS methodology for evaluation of accuracy, based on initial criteria values.

Bagocius et al. [5] developed a deep-water sea port in the Klaipeda region by a combination of WASPAS and entropy methods. Dejus and Antucheviciene [10] applied the entropy and WASPAS method for the assessment and selection of appropriate solutions for occupational safety. Siozinyte and Antucheviciene [40] proposed a rational solution to improve daylighting in vernacular buildings by applying AHP to determine the weightages and COPRAS, WASPAS, TOPSIS to rank the alternatives. Staniunas et al. [43] evaluated the greenhouse emissions and aimed at decreasing emissions significantly by applying COmplex PRoportional ASsessment (COPRAS), WASPAS and TOPSIS methodologies. Zavadskas et al. [48] selected the most preferable façade's alternative for public or commercial building by WASPAS and the results was also validated by MOORA and MULTIMOORA. Zolfani et al. [52] used Stepwise Weight Assessment Ratio Analysis (SWARA) method to calculate the relative weightages of the criteria and WASPAS method to evaluate the alternatives for selecting the perfect location to establish a shopping mall.

Chakraborty and Zavadskas [9] explored eight manufacturing decision making problems such as arc welding process, machinability of materials, cutting fluid selection, electro-discharge micro machining process parameters, industrial robot, electroplating system, milling and forging condition by the application of WASPAS method. Liu and Lin [29] assessed audit risk judgment by constructing a dominant IF rough set based MCDM methodology. Karande et al. [24] used couple of MCDM methods, i.e. MULTIMOORA, WASPAS, WPM, MOORA and WSM to investigate two real time industrial robot selection problems. Li et al. [28] proposed a new decision method to address the challenge on criteria reduction in MCDM problems with numerical values based on the rough set theory and the relation of criteria values. Venkateswarlu and Sarma [46] selected the best supplier for implementing the spring manufacturing industry by incorporating SAW and VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) methods.

Apart from this, many researchers also adopted different MCDM methods to choose the best alternatives used for domestic purposes like, Srichetta and Thurachon [41] evaluated the notebook selection problem by applying Fuzzy-AHP. Srikrishna et al. [42] used TOPSIS technique for a new car selection problem. Lakshmi et al. [27] and Tampi et al. [44] selected the best laptop model by using TOPSIS and AHP methodology. Adali and Isik [1] executed an air-conditioner selection problem with COPRAS and Additive Ratio ASsessment (ARAS) methods. Kalyani et al. [23] implemented extended TOPSIS method for selecting the best laptop model.

Agajie [4] adopted AHP to select the best personal computer on the basis of three criteria i.e. cost, user-friendliness and software availability.

From the above scenario of the literatures it is noticeable that, there are very few research works have been recorded till date where WSM, WPM and WASPAS methods are used for solving household decision making problems rather than the industrial applications. So, an initiative is taken in this article to utilize these three methods as a decision-making tool for solving a laptop selection problem. Moreover, MCDM is a quite straightforward

3. THEORETICAL ANALYSIS

All the three methods are explained clearly in details step by step under this section. There is not much difference between these methods and the initial steps of all the three methods starts with a decision matrix which is shown below by equation (3.1) followed by the normalization as shown in equations (3.2) and (3.3) [24].

$$[A_{ij}]_{m\times n} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{m1} & a_{m2} & a_{m3} & \cdots & a_{mn} \end{bmatrix}, \tag{3.1}$$

Where 'm' is the number of alternatives and 'n' is the number of criteria (i = *1, 2, 3…, m; j = 1, 2, 3…, n*).

Now, the normalization of the decision matrix is done by using equation (3.2) or (3.3) according to the criteria nature.

For beneficial criteria (maximum criteria) whose higher values are expected,

$$N_{ij} = \frac{a_{ij}}{a_j^{max}} \tag{3.2}$$

For non-beneficial criteria (minimum or cost criteria) whose smaller values are expected,

$$N_{ij} = \frac{a_j^{min}}{a_{ij}} \tag{3.3}$$

3.1. Weighted Sum Model (WSM)

WSM [11,30] is the most widely used MCDM tool [24] due to its simplicity and less complex calculations. The best option and the ranking are evaluated based on the overall weighted sum of the alternatives which is determined by using equation (3.4) shown below.

$$W_i^s = \sum_{j=1}^{n} N_{ij}\, W_j \tag{3.4}$$

3.2. Weighted Product Model (WPM)

WPM [32,45] is very similar to WSM [24] but instead of addition, multiplication is done and the criteria weightages are used as the power to the normalized values. Overall weighted product is determined for every alternative and the ranking is done based on these values. The weighted product values are determined by using equation (3.5).

$$W_i^p = \prod_{j=1}^{n} N_{ij}^{W_j}, \tag{3.5}$$

Where 'W_j' are the AHP computed weightages of criterion in equation (3.4) and (3.5).

3.3. Weighted Aggregated Sum Product Assessment Model (WASPAS)

WASPAS [48-50] is the combination of WPM and WSM where the aggregated sum product weightage is determined to rank the alternatives. A joint generalized criterion of the weighted summation and the multiplication methods is proposed by Zavadskas et al. [48,49] which is shown by equation (3.6) [24].

$$Q_i = 0.5W_i^s + 0.5W_i^p = 0.5\sum_{j=1}^{n} N_{ij}\, W_j + 0.5\prod_{j=1}^{n} N_{ij}^{W_j} \quad , \qquad (3.6)$$

Where, where Q_i is the aggregated sum product weightage of the *ith* alternative ($i = 1, 2, 3\ldots, m;$ $j = 1, 2, 3\ldots, n$).

In order to increase the effectiveness and the ranking accuracy, a more generalized equation was developed by Zavadskas et al. [50] which is given by equation (3.7) [24].

$$Q_i = \lambda W_i^s + (1\text{-}\lambda)W_i^p = \lambda\sum_{j=1}^{n} N_{ij}\, W_j + (1\text{-}\lambda)\prod_{j=1}^{n} N_{ij}^{W_j}, \qquad (3.7)$$

Where, where $\lambda = 0, 0.1, 0.2, 0.3\ldots, 1.$ From equation (3.7), if λ = 0 then it is converted to WPM and if λ = 1 then it is converted to WSM.

4. RESEARCH METHODOLOGY

Adali and Isik [2] solved a laptop selection problem by using MOORA, MULTIMOORA and MOOSRA method and the same problem is adopted in this present research work and further extended by analyzing through WSM, WPM and WASPAS method. In [2], they determined the criteria weightages using AHP which are kept constant in this analysis. The three methods are applied to the above stated problem and the output ranking of the alternatives are compared to the previous results. All the calculation details are covered in this section and the decision matrix as created by Adali and Isik [2] according to equation (3.1) is shown in Table 4.1 which is the initial step of the analysis.

Table 4.1. Selected alternative models and their specifications

Criteria Nature	Maxi	Maxi	Maxi	Maxi	Maxi	Maxi	Maxi	Maxi	Mini	Mini
Models	**PCS**	**CM**	**SS**	**DCS**	**R**	**SR**	**SD**	**BT**	**W**	**P**
LM1	3.5	6	1256	4	16	3	17.3	8	2.82	4100
LM2	3.1	4	1000	2	8	1	15.6	5	3.08	3800
LM3	3.6	6	2000	4	16	3	17.3	5	2.9	4000
LM4	3	4	1000	2	8	2	17.3	5	2.6	3500
LM5	3.3	6	1008	4	12	3	15.6	8	2.3	3800
LM6	3.6	6	1000	2	16	3	15.6	5	2.8	4000
LM7	3.5	6	1256	2	16	1	15.6	6	2.9	4000
Max or Min value	**3.6**	**6**	**2000**	**4**	**16**	**3**	**17.3**	**8**	**2.3**	**3500**

(Source: Adali and Isik, 2017)

Now the normalization of the decision matrix shown in Table 4.1 is done by using equations 3.2 and 3.3 based on the nature of the criteria. The maximum criteria (i.e. beneficial criteria) is normalized using equation 3.2 whereas, the minimum criteria (i.e. non-beneficial) is normalized using equation 3.3. The normalized decision matrix is shown in Table 4.2.

Table 4.2. Normalized matrix

Weights	**0.297**	**0.025**	**0.035**	**0.076**	**0.154**	**0.053**	**0.104**	**0.017**	**0.025**	**0.214**

	PCS	CM	SS	DCS	R	SR	SD	BT	W	P
LM1	0.972	1	0.628	1	1	1	1	1	0.816	0.854
LM2	0.861	0.667	0.5	0.5	0.5	0.333	0.902	0.625	0.747	0.921
LM3	1	1	1	1	1	1	1	0.625	0.793	0.875
LM4	0.833	0.667	0.5	0.5	0.5	0.667	1	0.625	0.885	1
LM5	0.917	1	0.504	1	0.75	1	0.902	1	1	0.921
LM6	1	1	0.5	0.5	1	1	0.902	0.625	0.821	0.875
LM7	0.972	1	0.628	0.5	1	0.333	0.902	0.75	0.793	0.875

(Source: Author's own elaboration)

The overall weighted sum (W_i^s) for each alternative is calculated by using equation (3.4). The calculated weighted sum is shown in Table 4.3 below.

Table 4.3. Overall weighted sum of the alternatives

	PCS	CM	SS	DCS	R	SR	SD	BT	W	P	Weighted sum
LM1	0.289	0.025	0.022	0.076	0.154	0.053	0.104	0.017	0.020	0.183	0.943
LM2	0.256	0.017	0.018	0.038	0.077	0.018	0.094	0.011	0.019	0.197	0.743
LM3	0.297	0.025	0.035	0.076	0.154	0.053	0.104	0.011	0.020	0.187	0.962
LM4	0.248	0.017	0.018	0.038	0.077	0.035	0.104	0.011	0.022	0.214	0.783
LM5	0.272	0.025	0.018	0.076	0.116	0.053	0.094	0.017	0.025	0.197	0.892
LM6	0.297	0.025	0.018	0.038	0.154	0.053	0.094	0.011	0.021	0.187	0.897
LM7	0.289	0.025	0.022	0.038	0.154	0.018	0.094	0.013	0.020	0.187	0.859

(Source: Author's own elaboration)

The overall weighted product (W_i^p) for each alternative is calculated by using equation (3.5). The calculated weighted sum is shown in Table 4.4 below.

Table 4.4. Overall weighted product of the alternatives

	PCS	CM	SS	DCS	R	SR	SD	BT	W	P	Weighted product
LM1	0.992	1	0.984	1	1	1	1	1	0.995	0.967	0.938
LM2	0.957	0.990	0.976	0.949	0.899	0.943	0.989	0.992	0.993	0.983	0.712
LM3	1	1	1	1	1	1	1	0.992	0.994	0.972	0.959
LM4	0.947	0.990	0.976	0.949	0.899	0.979	1	0.992	0.997	1	0.755
LM5	0.974	1	0.976	1	0.957	1	0.989	1	1	0.983	0.885
LM6	1	1	0.976	0.949	1	1	0.989	0.992	0.995	0.972	0.879
LM7	0.992	1	0.984	0.949	1	0.943	0.989	0.995	0.994	0.972	0.831

(Source: Author's own elaboration)

By using equation (3.7) a joint weightage of WSM and WPM is determined for every alternative. Now, λ value ranges from 0 to 1 at an interval of 0.1. So, eleven joint weightages are proposed for each and every alternative based on eleven λ values i.e. $\lambda = 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1$ in order to observe that, whether there will be some differences in the final output results and ranking for different λ values. The joint generalized criterion [24,50] weightages for different λ values are calculated and shown in Table 4.5.

Table 4.5. Joint generalized criterion weightages for different λ values

	$\lambda = 0$	$\lambda = 0.1$	$\lambda = 0.2$	$\lambda = 0.3$	$\lambda = 0.4$	$\lambda = 0.5$	$\lambda = 0.6$	$\lambda = 0.7$	$\lambda = 0.8$	$\lambda = 0.9$	$\lambda = 1$

LM1	0.938	0.939	0.939	0.940	0.940	0.941	0.941	0.941	0.942	0.942	0.943
LM2	0.712	0.715	0.718	0.721	0.724	0.727	0.730	0.733	0.737	0.740	0.743
LM3	0.959	0.959	0.959	0.959	0.960	0.960	0.960	0.961	0.961	0.961	0.962
LM4	0.755	0.758	0.761	0.764	0.766	0.769	0.772	0.775	0.777	0.780	0.783
LM5	0.885	0.885	0.886	0.887	0.888	0.888	0.889	0.890	0.891	0.892	0.892
LM6	0.879	0.881	0.882	0.884	0.886	0.888	0.890	0.891	0.893	0.895	0.897
LM7	0.831	0.833	0.836	0.839	0.842	0.845	0.848	0.850	0.853	0.856	0.859

(Source: Author's own elaboration)

From the above Table 4.5 it can be clearly seen that, for $\lambda = 0$, the joint weightages are exactly same as the weighted product shown in Table 4.4 since the first part of the equation (3.7) is eliminated in this case and on the other hand, when $\lambda = 1$, the second part of the equation (3.7) got eliminated so the joint weightages exactly matches with the weighted sum shown in Table 4.3.

5. RESULTS AND DISCUSSIONS

The weighted sum, weighted product and the joint generalized weightages are determined for every alternative by applying WSM, WPM and WASPAS method which are presented in Table 4.3, Table 4.4 and Table 4.5 respectively. Now according to the decreasing magnitude of these weightages, three ranking order of the alternatives can be done for each and individual methods which are presented in Table 5.1 (WSM and WPM) and Table 5.2 (WASPAS).

Table 5.1. Ranking of the alternatives by WSM and WPM

	WSM		**WPM**	
Alternatives	**Weighted sum**	**Rank**	**Weighted product**	**Rank**
LM1	0.943	2	0.938	2
LM2	0.743	7	0.712	7
LM3	0.962	1	0.959	1
LM4	0.783	6	0.755	6
LM5	0.892	4	0.885	3
LM6	0.897	3	0.879	4
LM7	0.859	5	0.831	5

(Source: Author's own elaboration)

Table 5.2. Ranking of alternatives by WASPAS

Alternatives	**λ = 0**	**Rank**	**λ = 0.1**	**Rank**	**λ = 0.2**	**Rank**	**λ = 0.3**	**Rank**	**λ = 0.4**	**Rank**	**λ = 0.5**	**Rank**
LM1	0.938	2	0.939	2	0.939	2	0.940	2	0.940	2	0.941	2
LM2	0.712	7	0.715	7	0.718	7	0.721	7	0.724	7	0.727	7
LM3	0.959	1	0.959	1	0.959	1	0.959	1	0.960	1	0.960	1
LM4	0.755	6	0.758	6	0.761	6	0.764	6	0.766	6	0.769	6
LM5	0.885	3	0.885	3	0.886	3	0.887	3	0.888	3	0.888	3
LM6	0.879	4	0.881	4	0.882	4	0.884	4	0.886	4	0.888	4
LM7	0.831	5	0.833	5	0.836	5	0.839	5	0.842	5	0.845	5

Alternatives	**λ = 0.6**	**Rank**	**λ = 0.7**	**Rank**	**λ = 0.8**	**Rank**	**λ = 0.9**	**Rank**	**λ = 1**	**Rank**
LM1	0.941	2	0.941	2	0.942	2	0.942	2	0.943	2
LM2	0.730	7	0.733	7	0.737	7	0.740	7	0.743	7
LM3	0.960	1	0.961	1	0.961	1	0.961	1	0.962	1

LM4	0.772	6	0.775	6	0.777	6	0.780	6	0.783	6
LM5	0.889	4	0.890	4	0.891	4	0.892	4	0.892	4
LM6	0.890	3	0.891	3	0.893	3	0.895	3	0.897	3
LM7	0.848	5	0.850	5	0.853	5	0.856	5	0.859	5

(Source: Author's own elaboration)

From the above two Tables 5.1 and 5.2, it can be clearly seen that all the three MCDM techniques are giving the same output results and suggest that Model 3 is the best laptop model among the group followed by Model 1 in the 2nd position whereas, Model 2 is the worst choice. All the rankings are more or less same with very little alteration. There is a very tough competition between Model 5 and Model 6 for the 3rd and 4th place.

From Table 5.1, WSM is suggesting that Model 6 should come in the 3rd place whereas, WPM is suggesting that Model 5 should occupy that place. To remove this confusion WASPAS is applied and the variations in ranking for all the values of λ is observed. It is noticeable in Table 5.2 that the ranking matches with the WPM ranking as the λ value varies from 0 to 0.4, since the second part of the equation (3.7) is given more importance in the favor of WPM. Similarly, as the λ value varies from 0.6 to 1 the ranking shifted towards the WSM, since the second part of the equation (3.7) slowly tends to zero and took the favor of WSM. So, in WASPAS method equal importance should be given to each WSM and WPM method by keeping the value of λ as 0.5 and it is suggested to use equation (3.6) while calculating the joint generalized weights. Hence, the ranking given by WASPAS method when $\lambda = 0.5$ can be accepted as the final ranking.

It should be noted, that the joint weights for Model 5 and Model 6 are given as same i.e. 0.888 in Table 5.2 under the column $\lambda = 0.5$ is due to round off error. If up to five decimal places are considered then for Model 5 and Model 6 the joint weights would be 0.88850 and 0.88775 which clearly shows that Model 5 should occupy the 3rd position and Model 6 should come in the 4th place. The present three rankings are also compared with the previous researchers results in Table 5.3 and graphically in Fig. 5.1 as proposed by Adali and Isik [2] using MOORA, MULTIMOORA and MOOSRA methods.

Table 5.3. Ranking comparisons of different MCDM methods

Alternatives	WSM	WPM	WASPAS	MOORA	MULTIMOORA	MOOSRA	Final ranking
LM1	2	2	2	2	2	2	2
LM2	7	7	7	7	7	7	7
LM3	1	1	1	1	1	1	1
LM4	6	6	6	6	6	6	6
LM5	4	3	3	3	3	3	3
LM6	3	4	4	4	4	4	4
LM7	5	5	5	5	5	5	5

(Source: Adali and Isik, 2017; Author's own elaboration)

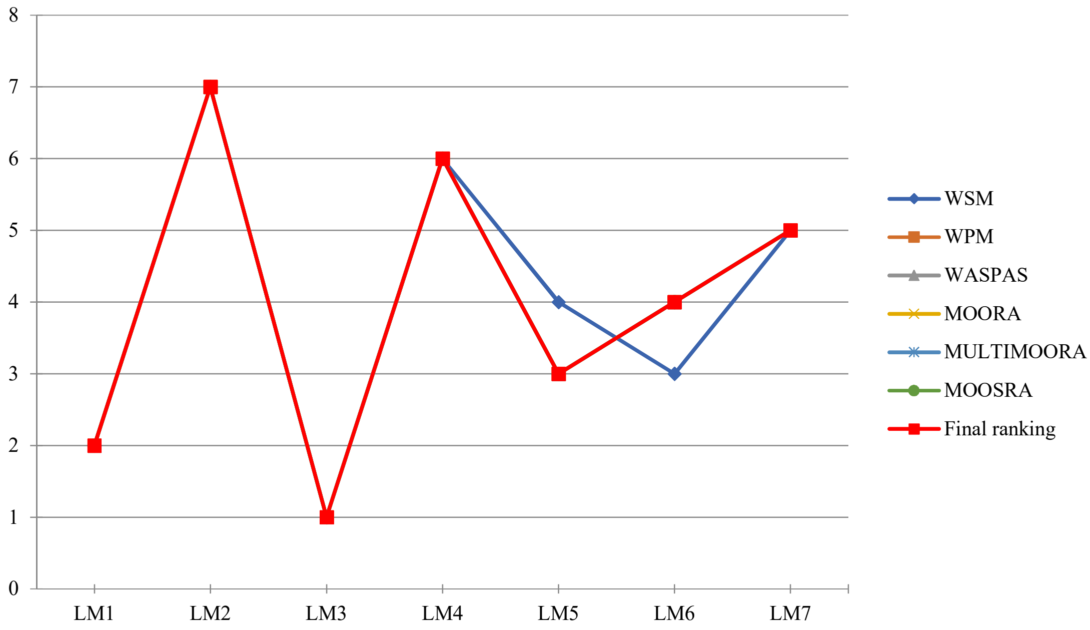

Fig. 5.1. Graphical comparisons of the proposed rankings
(Source: Author's own elaboration; Created using MS word chart option)

6. CONCLUSION

From the above research study, it can be concluded that Model 3 is the best laptop model followed by Model 1 among these chosen seven alternatives and Model 2 is the worst model to buy for the customers. The best and the worst choice of the alternatives suggested by all the six methods are exactly the same but, there is a very minor alternation in the WSM ranking regarding the 3rd and 4th places. Since, the ranking of the rest five MCDM methods shown in Table 5.3 exactly matches with each other so, the final ranking of the laptop models can be proposed as follows:

Model 3 > Model 1 > Model 5 > Model 6 > Model 7 > Model 4 > Model 2

Limitations: There are lots of MCDM tools available whose implementation to the same problem may generate different output results and ranking. Moreover, if different subjective or objective weightage calculation methods are used other than AHP like, CRiteria Importance Through Inter criteria Correlation (CRITIC), Entropy, Best Worst Method (BWM) etc. it may also alter the final results.

Future scope: Different MCDM methods can be applied to the above problem and the ranking can be compared with these proposed rankings. The criteria weightages can also be determined by other methods and the variation in results can be noted. Not only these but also, MCDM tools can also be utilized as a decision tool in the selection of other electronic gadgets and household appliances e.g. television, washing machine, camera etc.

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