Product Evaluation Using Entropy and Multi Criteria Decision Making Methods

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Abstract: There is variety of products of different brands available in the market for the customer of different levels which can satisfy their specific demands. The customer has been offered by means of variety of products of the same species and category with different features and attribute. This enhance the competition between the brands, resultantly make efforts to stimulate the customers towards their products by means of different policies, which sometimes can make customer confuse between the brands and their products to – what to pick and what not to. In this research paper we have taken nine laptops of different brands of nearly same range of specifications and Multi Criteria Decision Making (MCDM) Methods are applied to choose the best option among the different alternatives. Entropy method is used to evaluate the weight of the feature attributes.

Keywords -Multi Criteria Decision Making Methods, Entropy, TOPSIS, Advance TOPSIS, SAW, WPM.

I. INTRODUCTION

There is wide range of laptop available in market with unique features and attributes. Based on different demands of the customer, manufacturers have to provide different variety of the product with different attributes and features. Customers get difficulty in selecting the best product from the ranges available in market. Multi criteria decision making method provides ranking solution to differentiate the range on the basis of product feature and product attributes. In this research paper Multi Criteria Decision Making Methods {Simple Additive Method (SAW), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Advance TOPSIS, Weighted Product Method(WPM) } are applied on different brands of laptop to choose the best option among the different alternatives. The specifications of the products taken under study are listed in the TABLE I, later in the paper. Entropy method is used to evaluate the weight of the feature attributes.

II. METHODOLOGY

To find out the best quantitative solution from the alternatives, multi criteria decision making process provides ranking solution of the alternatives to select the best alternatives. In this research paper we applied entropy method because it is highly reliable for information measurement and provide high accuracy in determination of weight of the feature attribute of the product. A MCDM problem can be expressed in matrix format as:

$$D = \begin{matrix} * \\ A1 \\ A2 \\ A3 \\ \vdots \\ Am \end{matrix} \begin{bmatrix} C1 & C2 & C3 & \cdots & Cn \\ x11 & x12 & x13 & \cdots & x1n \\ x21 & x22 & x23 & \cdots & x2n \\ x31 & x32 & x33 & \cdots & x3n \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ xm1 & xm2 & xm3 & \cdots & xmn \end{bmatrix}$$

$$W = [w1 \quad w2 \quad w3 \quad \ldots \quad wn]$$

Where *A1*, *A2*, *A3* ...., *Am* are possible alternatives among which decision makers have to choose, *C1*, *C2*, *C3*, ..., *Cn* are criteria with which alternatives performance are measured, *xij* is the performance value of alternatives *Ai* with respect to criterion *Cj*, *wj* is the weight of criterion *Cj*.

A) ENTROPY

According to the degree of index dispersion, the weight of all indicators is calculated by information entropy.

Suppose we have a decision matrix B with *m* alternatives and *n* indicators:

Step 1: In matrix B, feature weight P_{ij} is of the j^{th} alternatives to the j^{th} factor:

$$p_{ij} = \frac{xij}{\sum_{i=1}^{m} xij}, \quad (1 \le i \le m,\ 1 \le j \le n)$$

Step 2: The output entropy e_j of the j^{th} factor becomes

$$e_j = -k \sum_{i=1}^{m} pij \ln pij, \quad (k = 1/\ln m,\ 1 \le j \le n)$$

Step 3: Variation coefficient of the j^{th} factor: g_j can be defined by the following equation:

$$d_j = 1 - e_j, \quad (1 \le j \le n)$$

Step 4: Calculate the weight of entropy w_j:

$$w_j = gj / \sum_{i=1}^{m} gj, \quad (1 \le j \le n)$$

B) TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION (TOPSIS)

Technique for order preference by similarity to ideal solution TOPSIS was initially developed by Hwang and Yoon (1981). TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution (Jahanshahloo et al., 2006). All alternative solutions can be ranked according to their closeness to the ideal solution.

Step 1: Calculate the normalized decision matrix A. The normalized value (*aij*) is calculated as:

$$aij = \frac{xij}{\sum_{i=1}^{m}(xij)2} \quad ,(1 \le i \le m, 1 \le j \le n)$$

Step 2: Calculate the weighted normalized decision matrix:

$$V = (\, a_{ij} * w_j)$$

Where w_j is the weight of the i^{th} criterion and $\sum_{i=1}^{n}, w = 1$.

Step 3: Calculate the ideal solution V^+ and the negative ideal solution V^-

$$V^+ = \{v_1^+, v_2^+,.. v_n^+\} = \{ \text{Max } v_{ij} \mid j\in J), (\text{Min } v_{ij} | j\in J)\}$$

$$V^- = \{v_1^-, v_2^-,.. v_n^-\} =\{ \text{Min } v_{ij} \mid j\in J), (\text{Max } v_{ij} | j\in J)\}$$

Step 4: Calculate the separation measures, using the m-dimensional Euclidean distance

$$S+ = \sqrt{\sum_{j=1}^{n}(V_{ij} \quad - \quad V^+)^2}, \text{ where } (1 \le i \le m, 1 \le j \le n)$$

$$S- = \sqrt{\sum_{j=1}^{n}(V_{ij} \quad - \quad V^-)^2}, \text{ where } (1 \le i \le m, 1 \le j \le n)$$

Step 5: Calculate the relative closeness to the ideal solution

$$Pi = \frac{S_i^-}{S_i^+ \ + \ S_i^-} \qquad (1 \le i \le m, 1 \le j \le n)$$

Where the larger is, P_i the closer the alternative is to the ideal solution.

Step 6: The larger TOPSIS value, the better the alternative.

C) MODIFIED TOPSIS

In this method, the positive ideal solution (R^+) and negative ideal solution (R^-) are not dependent on the weighted decision matrix and can be represented as follows:

$$R^+ = \{R_1^+, R_2^+,.. R_n^+\} = \{ \text{Max } R_{ij} \mid j\in J), (\text{Min } R_{ij} | j\in J)\}$$

$$R^- = \{R^-, R_2^-,.. R_n^-\} =\{ \text{Min } R_{ij} \mid j\in J), (\text{Max } R_{ij} | j\in J)\}$$

The weighted Euclidean distances are calculated follows:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} wj(Rij \quad - \quad Rj^+)^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} wj(Rij \quad - \quad Rj^-)^2}$$

The relative closeness of particular alternative to the ideal solution Pi can be determined as follows:

$$Pi = \frac{S_i^-}{S_i^+ \ + \ S_i^-}$$

D) SIMPLE ADDITIVE WEIGHTING (SAW)

$$Vi = \sum_{J=1}^{n} wj\, rij \quad i = 1 \ldots, m$$

E) WEIGHT PRODUCT METHOD (WPM)

$$Pi = \prod_{J=1}^{m} [(yij)\,]\text{^}\, wj$$

III. APPLICATION

In this research paper to demonstrate the above mentioned decision making approaches an example can be considered as follows:

According to customers requirement 9 personal data assistant design alternatives P1, P2, P3, P4, P5, P6, P7, P8 and P9 selected are shown in following TABLE I. Laptop is chosen for ranking comparison.

TABLE I
Specification of 9 different laptops available in market

Products	Dimension (mm)	Weight (kg)	Size (Inch)	RAM (GB)	Bluetooth	Camera (MP)	Processing Speed (GHz)	Hard Disk (GB)	Price (Rs.)
P1	2273852	2.22	14	4.0	2.0	0.3	2.1	500	40430
P2	2513700	2.10	14	4.0	2.1	1.5	2.26	640	39820
P3	2340832	2.43	14	4.0	3.2	2.0	2.53	500	48830
P4	1970240	2.68	15.6	4.0	2.0	0.3	2.0	640	43120
P5	2456244	2.20	14	2.0	2.0	1.3	2.3	500	36510
P6	3125928	2.14	14	2.0	2.1	0.3	2.26	320	42680
P7	2386393.5	2.40	15.6	4.0	3.0	0.3	2.4	500	44920
P8	2854493.5	2.70	15.5	4.0	2.1	0.3	2.93	500	46260
P9	2322060	2.26	14	3.0	2.1	0.3	2.66	320	40750

The ENTROPY method is applied to evaluate the weight of each attribute. The evaluation process is shown in TABLE II.

TABLE II
ENTROPY: Normalization Matrix for weight calculations

Products	Dimension (mm)	Weight (Kg)	Size (Inch)	RAM (GB)	Bluetooth	Camera (MP)	Processing Speed (GHz)	Hard Disk (GB)	Price (Rs.)
P1	-0.2247	-0.2366	-0.2392	-0.2641	-0.2263	-0.1406	-0.2275	-0.2465	-0.2371
P2	-0.2377	-0.2294	-0.2392	-0.2641	-0.2327	-0.3367	-0.2371	-0.2797	-0.2351
P3	-0.2284	-0.2487	-0.2392	-0.2641	-0.2892	-0.3618	-0.2522	-0.2465	-0.2625
P4	-0.2066	-0.2618	-0.2537	-0.2641	-0.2263	-0.1406	-0.2211	-0.2797	-0.2458
P5	-0.2348	-0.2356	-0.2392	-0.1768	-0.2263	-0.3200	-0.2293	-0.2465	-0.2238
P6	-0.2670	-0.2318	-0.2392	-0.1768	-0.2328	-0.1406	-0.2371	-0.1899	-0.2443
P7	-0.2960	-0.2470	-0.2537	-0.2641	-0.2806	-0.1406	-0.2450	-0.2465	-0.2511
P8	-0.2546	-0.2629	-0.2528	-0.2641	-0.2328	-0.1406	-0.2720	-0.2465	-0.2552
P9	-0.22273	-0.2391	-0.2392	-0.2259	-0.2328	-0.1406	-0.2588	-0.1899	-0.2382

TABLE III
ENTROPY: Weight calculations

Product	Dimension (mm)	Weight (kg)	Size (Inch)	RAM (GB)	Bluetooth	Camera (MP)	Processing Speed (GHz)	Hard Disk (GB)	Price (RS.)
Ej	0.9908	0.9908	0.9992	0.9849	0.9920	0.8474	0.9922	0.9884	0.9982
dj	0.0092	0.0020	0.0008	0.0151	0.0080	0.1526	0.0078	0.0116	0.0018
wj	0.0440	0.0096	0.0038	0.0723	0.0383	0.7305	0.0373	0.0555	0.00862

Now applying different Multi Criteria Decision Making Methods for obtaining ranking solution of the product for which the above data is converted into normalization matrix as shown in TABLE IV.

TABLE IV
MCDM: Normalization Matrix

Products	Dimension (mm)	Weight (Kg)	Size (Inch)	RAM (GB)	Bluetooth	Camera (MP)	Processing Speed (GHz)	Hard Disk (GB)	Price (Rs.)
P1	0.2815	0.3140	0.3210	0.3763	0.2857	0.1031	0.2921	0.3316	0.3153
P2	0.3112	0.2970	0.3210	0.3763	0.3000	0.5154	0.3143	0.4244	0.3106
P3	0.2898	0.3437	0.3210	0.3763	0.4571	0.6872	0.3520	0.3316	0.3808
P4	0.2439	0.3790	0.3576	0.3763	0.2857	0.1031	0.2782	0.4244	0.3363
P5	0.3041	0.3112	0.3210	0.1881	0.2857	0.4467	0.3198	0.3316	0.2847
P6	0.3870	0.3027	0.3210	0.1881	0.3000	0.1031	0.3143	0.2122	0.3329
P7	0.4802	0.3394	0.3576	0.3763	0.4286	0.1031	0.3338	0.3316	0.3504
P8	0.3534	0.3818	0.3553	0.3763	0.3000	0.1031	0.4075	0.3316	0.3608
P9	0.2875	0.3196	0.3210	0.2822	0.3000	0.1031	0.3699	0.2122	0.3178

TABLE V
Ranking obtained by TOPSIS

Product	S_i^+	S_i^-	P_i	Ranking
P1	0.4245	0.0152	0.2562	VI
P2	0.2576	0.3017	0.6101	III
P3	0.0995	0.4269	0.7635	I
P4	0.4171	0.0180	0.3116	V
P5	0.1769	0.2682	0.4630	II
P6	0.4297	0.0065	0.3711	IX
P7	0.4404	0.0193	0.8612	IV
P8	0.4267	0.0166	0.5527	VII
P9	0.4269	0.0079	0.1748	VIII

TABLE VI
Ranking obtained by Modified TOPSIS

Product	Modified TOPSIS	Ranking
P1	0.2562	VIII
P2	0.6101	III
P3	0.7635	II
P4	0.3116	VII
P5	0.4630	V
P6	0.3711	VI
P7	0.8612	I
P8	0.5527	IV
P9	0.1748	IX

TABLE VII
Ranking obtained by SAW

Product	SAW	Ranking
P1	0.162098	VII
P2	0.470920	II
P3	0.598799	I
P4	0.166022	VI
P5	0.401230	III
P6	0.147927	IX
P7	0.178557	IV
P8	0.171289	V
P9	0.152459	VIII

TABLE VIII
Ranking obtained by WPM

Product	WPM	Ranking
P1	0.14269	VII
P2	0.47275	II
P3	0.58515	I
P4	0.14372	VI
P5	0.39909	III
P6	0.13477	IX
P7	0.14916	IV
P8	0.14636	V
P9	0.13794	VIII

TABLE IX
Comparison of ranking

Multi Criteria Decision making Methods	Ranking of Products
TOPSIS	VI-III-I-V-II-IX-IV-VII-VIII
Modified TOPSIS	VIII-III-II-VII-V-VI-I-IV-IX
SAW	VII-II-I-VI-III-IX-IV-V-VIII
WPM	VII-II-I-VI-III-IX-IV-V-VIII

IV. CONCLUSION

On the basis of quantitative approach for ranking comparison of different laptop as shown in TABLE IX, it clearly indicates that TOPSIS, SAW and WPM are in favor of product alternative P3. Hence compared to remaining alternatives, product alternative P3 is much better than rest of the alternative products.

V. REFERENCE

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