The Application of Multiple Attribute Decision in LED Commerce Platform

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Abstract

The paper applied multiple attribute decision making into LED collaborative commerce platform to help customers make purchase decision. The normal customers are unfamiliar with LED lighting product, because it is latest product in lighting industry and the attributes of LED are complicated and professional. The method analyzed the essential attributes and network attributes of LED lighting products to sequence the limited alternative. And based on the shortage of TOPSIS method, the paper combined grey correlation with TOPSIS method in order to make decision more exactly.

Keywords*: LED lighting product, e-commerce, multiple attribute decision making*

1. Introduction

LED is the emerging industry in China. With 30 year's development, the LED industry has become the relatively integrated industrial cluster. The government put more attentions to the LED industry and makes the development goal bigger after the latest five-year plan [1]. The LED lighting products will be imported into most of normal family in the near future.

But for the LED lighting enterprise, it is hard to make the LED lamps be accepted by the traditional distribution at the present stage, and it needs lots of funding. As an online shopping, it is cheap and widely spread. At present, there are lots of LED industries pay attentions to e-commerce. They make e-commerce as their mainly marketing channel.

Because of the unfamiliar with LED lighting products, most of customers can't make the exactly decision when they do LED purchase in internet. Considering the special attributes of LED products, the paper integrates multiple attribute decision making method with online shopping. The method helps customers make decision through the decision analysis.

2. Analysis of TOPSIS based on Grey Correlation
2.1. The Introduction of MADA

Multiple attribute decision making (MADA) is the decision problem that choosing the best alternative scheme or sequencing limited decisions alternative in the condition of considering multiple attribute [2].

There are mainly four parts in the process of solving multiple attribute decision problems. There are standardizing decision matrix, building mathematical model, confirming weight and ordering offers. Figure 1 intuitively describes the process [3].
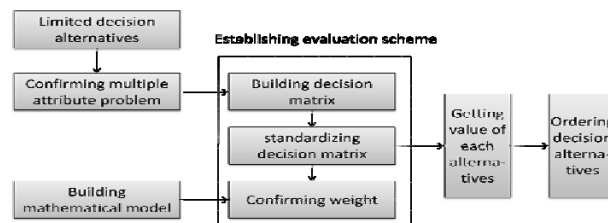

Figure 1. The Process of Decision Making

2.2. Analysis of TOPSIS based on Grey Correlation

TOPSIS is the abbreviation of technique for order preference by similarity to ideal solution. The basic idea of TOPSIS is that getting the distance to ideal solution as judgement standard through building positive ideal solution and negative ideal solution which is based on theory of ideal solution in alternative schemes.

TOPSIS method can reflect the entire similarity of alternative scheme and ideal scheme through function curves. But it can't primely reflect the differences between variation trend of internal attributes of alternative scheme and ideal scheme. The analysis is only based on original data sample. It is hard to ensure the exactness of decision result if just analyzing the sample data in the condition of limited information. Grey correlation method can reflect the differences between variation trend of internal attributes of alternative scheme and ideal scheme well, and it is suitable for the evaluation condition of partial information known or partial information unknown. But there still exists defect in the whole evaluation condition. So the paper combined the TOPSIS with gray correlation to create a new Gray ideal value approximation model [4].

The specific procedure is as follows:
1. Confirming attribute matrix A.

2. Standardizing decision matrix $\overline{A}$.
3. Getting weighting value V.

4. Confirming weighting judgment matrix $W=V\overline{A}$.
5. Confirming positive ideal solution and negative ideal solution.

$$A^+ = \max v_{ij} , \ A^- = \min v_{ij} \tag{1}$$

6. Calculating the distance of alternative scheme to ideal solutions.

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_{ij}^+)^2} , \ S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_{ij}^-)^2} \tag{2}$$

7. Calculating grey correlation degree of alternative scheme to ideal solutions.

$$\eta_{ij} = \frac{\min\min\left|v_j^+ - v_{ij}\right| + \xi \max\max\left|v_j^+ - v_{ij}\right|}{\left|v_j^+ - v_{ij}\right| + \xi \max\max\left|v_j^+ - v_{ij}\right|} \tag{3}$$

ξ is resolution ratio. The range of ξ is 0< ξ <1. ξ equals 0.5 ordinary. Grey correlation degree is the average value of η_{ij} .

$$D_i = \frac{1}{n}\sum_{j=1}^{n}\eta_{ij} \tag{4}$$

8. Converting distance and grey degree into proper dimensionless indexes.

$$T = T_i / \max(T_i), T_i = S_i^+, S_i^-, D_i^+, D_i^- . \tag{5}$$

9. Calculating the relative similarity degree of distance and grey degree after converting.

$$r_i^+ = a_1 S^+ + a_2 D^+, r_i^- = a_1 S^- + a_2 D^-, a_1 + a_2 = 1 . \tag{6}$$

Getting the similarity degree:

$$u_i = \frac{r_i^+}{r_i^+ + r_i^-}$$ (7)

Through the calculating, the biggest similarity degree is the best scheme.

3. The Study of LED Multiple Attribute Decision Model
3.1. Building LED Multiple Attribute Decision Model

The choice of attributes will affect the result of decision making of certain decision alternatives. The size of attribute set and distinction of attributes will involve the decision process complexity. Therefore, it is important to decide the attribute set reasonably during the process of building decision matrix [5].

Classify attributes as follows:

1. Attribute is divided into quantitative attribute and qualitative attribute. As above LED working life, power and working temperature are quantitative attributes. The value can be described in style of accurate real number, interval number and fuzzy number. Some attributes can't get quantitative value, so decision maker can only give the estimated description in qualitative style. Such as LED material, LED chip brand and energy saving effect are qualitative attributes.

2. The attribute can be divided into benefit type, cost type, fixated type, interval type, deviation type and deviation interval type through people expectation to attribute value.

LED lighting product parameters are mainly divided into optic parameters (luminous intensity, luminous flux, radiation intensity, wavelength etc.), electrical parameters (threshold voltage, forward current, forward drop, reverse current, switch time etc.) and thermology parameters (junction temperature, thermal resistance, shell temperature etc.). Besides these parameters, there are working lifes, safety performance etc. It is necessary to consider different parameters based on different application areas.

Customers will pay more attention to LED lighting products normal attributes when they make purchase decision. Such as price, power, appearance style, material, working life etc. But as a new type luminous product, LED has its own special characters [6].

1. LED chip. LED chip are divided into domestic and import. The imports mainly import from American, Japan, Korea, Taiwan etc. The top quality chip is from American and Japan. The qualities of chip almost decide the quality of LED lighting product in significant measure.

2. LED lighting effect. Lighting effect is defined as the result of dividing luminous flux by corresponding power.

3. LED color rendering index. Color rendering index is defined as the realistic degree that lighting sources show the color. Because of the luminous theory LED lighting source has shortage in the field of color rendering. Customers should consider the color rendering combining with special scene when they buy LED lighting products.

4. LED luminous flux. The radiant power is the total radiated power in watts. This power must be factored by the sensitivity of the human eye to determine luminous flux in lumens. The most important function of lighting products is lighting. Customers can't just pursue the power. Because the lighting effect is not power but luminous flux. The LED luminous flux is 3-4 times of traditional lighting product in some power.

5. LED lighting product material. The common material is aluminum alloy and pure aluminum. Aluminum alloy has low density, high intensity which is equal even better than high-quality steel and good plasticity which can be processed into various section bars. It also has excellent electro conductibility, temperature conductivity and corrosion stability. Pure aluminum is divided into cast aluminum and lathe aluminum through different processing techniques. Lathe aluminum is better than cast aluminum in the field of heat-conducting property.

Besides these attributes above, customers should consider other attributes on the basis of specific working places.

Decision alternatives of LED lighting products are expressed as follows [7]:

$$A = \{A_1, A_2, ..., A_i\}, (i \geq 2)$$ (8)

$$F = \{f_1, f_2, ..., f_j\}, (j \geq 2)$$ (9)

LED lighting products set is described as formula 8, LED lighting products attributes set is described as formula 9. Table 1 is multiple attribute decision tables.

Table 1. Multiple Attribute Decision Table

Decision alternatives	f_1	......	f_j
A_1	x_{11}	......	x_{1j}
A_2	x_{21}	......	x_{2j}
......	......	......	......
A_i	x_{i1}	......	x_{ij}

Structuring multiple attribute decision matrixes (10) from Table 1:

$$A = \begin{pmatrix} x_{11} & x_{12} & ... & x_{1j} \\ x_{21} & x_{22} & ... & x_{2j} \\ ... & ... & ... & ... \\ x_{i1} & x_{i2} & ... & x_{ij} \end{pmatrix} \tag{10}$$

3.2 Standardizing Decision Matrix

There are various methods to standardize decision matrix. In this paper, the author uses range transformation method. Because the method has convenient transform and excellent character, it is used broadly in MADA at present.

The basic theory of range transformation is making the best attribute's value equals 1, making the worst attribute's value equals 0. The rest of attributes' values are standardized in linear differentials method [8].

Benefit type attribute:

Making $\max_i x_{ij} \to 1$ (Standardizing $\max_i x_{ij}$ to 1), $\min_i x_{ij} \to 0$. And use linear differentials method to get standardization value b_{ij}:

$$b_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, (i = 1,...,m) \tag{11}$$

Cost type attribute:

Making $\max_i x_{ij} \to 0$ (Standardizing $\max_i x_{ij}$ to 1), $\min_i x_{ij} \to 1$. Getting transform:

$$b_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}}, (i = 1,...,m) \tag{12}$$

Because of the length of article, the details of other attribute types standardization see in reference [9].

Attribute set A was standardized to $\overline{A}$:

$$\overline{A} = \begin{pmatrix} b_{11} & b_{12} & ... & b_{1j} \\ b_{21} & b_{22} & ... & b_{2j} \\ ... & ... & ... & ... \\ b_{i1} & b_{i2} & ... & b_{ij} \end{pmatrix} \tag{13}$$

3.3. Confirming LED Lighting Products' Attribute Weight

The decision alternatives were chosen by online customers through their own preferences. In the paper, author combined subjective weighting method with objective weighting method. Subjective weighting method is entropy. The principle of entropy is that the difference between certain attribute is bigger, the entropy is smaller. Therefore the weight of the attribute is bigger. The details of the method are as follows [9]:

1. Normalized matrix $\bar{A}$ to P:

$$p_{ij} = \frac{b_{ij}}{\sum\limits_{i=1}^{m} b_{ij}} (i = 1, 2, ..., m, j = 1, 2, ..., n) \tag{14}$$

2. Defining the comentropy of evaluation index as:

$$E_j = -\frac{1}{\ln m} \sum_{i=1}^{m} (p_{ij} \ln p_{ij})(i = 1, 2, ..., m, j = 1, 2, ..., n) \tag{15}$$

3. Getting the weight value of attribute j:

$$v_j = \frac{1 - E_j}{\sum\limits_{k=1}^{n} (1 - E_k)} (j = 1, 2, ..., n) \tag{16}$$

From the above, we got the objective weight vector:

$$v = (v_1, v_2, ..., v_n)^T \tag{17}$$

Online customers have their own preferences to attribute set. Customer gets subjective weight λ_j. Then, subjective weight λ_j was combined with v_j. We finally got the more exactly weight v_j^o [10].

$$v_j^o = \frac{\lambda_j v_j}{\sum\limits_{j=1}^{n} \lambda_j v_j}, (j = 1, 2, ..., n) \tag{18}$$

4. The Application of TOPSIS MADA based on Grey Correlation
4.1. The Analysis of Application

Online shopping is a psychological and decision process including requirement identification, information collecting, psychological known, purchase decision and evaluation. The paper applies the method into LED e-commerce platform to help customers to make decision during the process of purchase decision.

The paper studied on 4 kinds of 5W LED bulb lamps. Illumination design is different in different application scenarios. Therefore, the requirements of lamp are different. The paper chosen dining room as application scenario to analyze.

Through the study of lighting requirements in dining room, Table 2 shows the details of those attributes.

Table 2. LED Bulb Lamps Multiple Attribute Decision Table

Attribute / LED	Price (¥)	Material	Working life (hour)	Guarantee life (Year)	Color temperature (K)	Color Rendering (Ra)	Luminous effect (lm)	Lighting effect (lm/w)	Irritation angle (°)	LEDchip brand
Bulb 1	22	Cast aluminum	50000	1	3000	70	450	100	120	Domestic
Bulb 2	25	Cast aluminum	50000	2	4000	75	500	110	180	Domestic
Bulb 3	22	Lathe aluminum	15000	2	3200	85	500	105	60	Taiwan
Bulb 4	38	Aluminum alloy	50000	2	3300	70	360	85	90	Korea LG
Evaluation index	Cost	Qualitative	Benefit	Benefit	Interval	Benefit	Benefit	Benefit	Fixated	Qualitative

The ideal color temperature is 3300~5000k because that the comfortable photochromic in dining room is warm color. The ideal irritation angle is 90°because that the lighting in dining room is accent lighting.

Qualitative type attribute should be transformed into quantitative attribute. In the paper, the granularity value of linguistic set is 5. From above analysis, we got the correspondence value of the qualitative attributes showed in Table 3.

Table 3. Transformation of Qualitative Type Attribute

Qualitative	Worst	Worse	Good	Better	Best
Quantitative	1	3	5	7	9
Material			Cast aluminum	Lathe aluminum	Aluminum alloy
Brand			Domestic	Taiwan	Korea LG

Because the method is applied in online shopping, it is necessary to considering the network evaluation, transaction volume and express evaluation in the building of attribute matrix. Table 4 shows the correspondence value of 4 lamps.

Table 4. Transformation of Qualitative Type Attribute

Network attributes	network evaluation	transaction volume	express evaluation
Bulb 1	5	2802	4.8
Bulb 2	4.7	1286	5
Bulb 3	4.8	1785	4.9
Bulb 4	5	906	5

4.2. Model Solution

1. Getting the decision matrix A through Table 2-4:

$$A = \begin{bmatrix} 22 & 5 & 50000 & 1 & 3000 & 70 & 450 & 100 & 120 & 5 & 5 & 2802 & 4.8 \\ 25 & 5 & 50000 & 2 & 4000 & 75 & 500 & 110 & 180 & 5 & 4.7 & 1286 & 5 \\ 22 & 7 & 15000 & 2 & 3200 & 85 & 500 & 105 & 60 & 7 & 4.8 & 1785 & 4.9 \\ 38 & 9 & 50000 & 2 & 3300 & 70 & 360 & 85 & 90 & 9 & 5 & 906 & 5 \end{bmatrix}$$

2. Getting the standardization matrix through range transformation method:

$$\bar{A} = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0.64 & 0.6 & 0.67 & 0 & 1 & 1 & 0 \\ 0.81 & 0 & 1 & 1 & 1 & 0.33 & 1 & 1 & 0 & 0 & 0 & 0.2 & 1 \\ 1 & 0.5 & 0 & 1 & 0.67 & 1 & 1 & 0.8 & 0.67 & 0.5 & 0.33 & 0.46 & 0.5 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \end{bmatrix}$$

3. Getting the objective weight value v through formula 14-17:

$$v = (0.052, 0.133, 0.052, 0.052, 0.054, 0.146, 0.054, 0.057, 0.054, 0.133, 0.069, 0.084, 0.059)^T$$

The customer preference weight is λ :

$$\lambda = (0.2, 0.05, 0.03, 0.05, 0.05, 0.1, 0.08, 0.06, 0.02, 0.09, 0.2, 0.01, 0.06)^T$$

Getting the combined weighting v^o through formula 18:

$$v^o = (0.134, 0.086, 0.02, 0.034, 0.035, 0.188, 0.056, 0.044, 0.014, 0.154, 0.178, 0.011, 0.046)^T$$

Getting weighting judgment matrix W:

$$W \equiv v^o \bar{A} = \begin{bmatrix} 0.134 & 0 & 0.02 & 0 & 0 & 0 & 0.03584 & 0.0264 & 0.00938 & 0 & 0.178 & 0.011 & 0 \\ 0.10854 & 0 & 0.02 & 0.034 & 0.035 & 0.06204 & 0.056 & 0.044 & 0 & 0 & 0 & 0.0022 & 0.046 \\ 0.134 & 0.043 & 0 & 0.034 & 0.02345 & 0.188 & 0.056 & 0.0352 & 0.00938 & 0.077 & 0.05874 & 0.00506 & 0.023 \\ 0 & 0.086 & 0.02 & 0.034 & 0.035 & 0 & 0 & 0 & 0.014 & 0.154 & 0.178 & 0 & 0.046 \end{bmatrix}$$

Getting the distance of alternative scheme to ideal solutions through formula 2:

$$S_i^+ = (0.2678, 0.2821, 0.1523, 0.2419)$$

$$S_i^- = (0.2285, 0.1600, 0.2670, 0.2606)$$

4. Getting correlation degree of alternative scheme to ideal solutions through formula 3-4:

$$D_i^+ = (0.5953, 0.6823, 0.6662, 0.7436)$$

$$D_i^- = (0.6869, 0.5668, 0.4989, 0.5897)$$

5. Getting the relative similarity degree of distance and grey degree after converting through formula 6-7, defined $a_1 = a_2 = 0.5$:

$$u_i = (0.4853, 0.4541, 0.5738, 0.5031)$$

6. Ordering u_i : $u_3 > u_4 > u_1 > u_2$

Through the above processes, we got that bulb 3 is the best choice. LED bulb lamp 3 has good quality though the working life is the shortest in the 4 lamps. The weight value of working life is small and 15000h is enough for the customer's requirement.

5. Conclusion

LED is the emerging industry in China and the attributes of LED lighting products are various. In this study application of multiple attribute decision making in LED lighting products online shopping is studied. Because of the shortage in TOPSISI method, the paper combined grey correlation with TOPSIS as decision method. The method is applied in LED e-commerce platform. Through the decision method, it is easy to make purchase decision for customer. In the next research, it is important to consummate attribute set in condition of different application areas and ensure the accuracy of decision result.

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