Preference of Corporate Charitable Donation Field Based on AHP-Topsis Model

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Abstract: According to the characteristics of corporate charitable donation behavior, the evaluation system of charitable donation field is established from the donation field and corporate business relevance, the social media attention, the number of potential customers and the willingness of leaders and employees. The weight of each evaluation index is determined by Analytic Hierarchy Process (AHP), and then the preferential model of corporate charitable donation field is established by combining Technique for Order Preference by Similarity to an Ideal Solution (Topsis). Finally, the AHP-Topsis model is used to compare and select the six fields to which a green technology real estate company may make donations. According to the results, the comprehensive superiority in the field of ecological environment is the best, up to 76.9%. The evaluation results match the actual corporate donation field, and the model can be applied to the preference decision in the corporate charitable donation field.

1. Introduction
With the continuous progress of building a well-off society in an all-round way, it has become a trend for enterprises to actively participate in social charity. According to statistics from Blue Book of Philanthropy: Annual Report on China's Philanthropy Development (2019)[1], private enterprises donate about RMB 45.032 billion for the whole year, and state-owned enterprises donate RMB 31.09 billion for the whole year. Manufacturing, real estate, finance and other industries make the highest donations, with donation areas mainly concentrated in poverty alleviation, environmental protection, educational development and medical assistance. By participating in charity, enterprises can not only enhance their images, improve the business environment, train potential customers and better manage stakeholders, but also play an important role in regulating the redistribution of resource income, alleviating the gap between rich and poor, easing social contradictions, promoting social equity, etc. [2] However, the industry to which an enterprise belongs, the products and services provided, the production characteristics and the needs of external stakeholders are different, thus different donation fields can bring different behavioral benefits to enterprises and enterprise decision makers, and directly affect the enthusiasm of enterprises to make donations here [3-4]. However, the research of domestic scholars mainly focuses on the comparative analysis of corporate charity fields between China and foreign countries [5-6]. Based on the collection of literature and the full absorption of the existing research results, this paper analyzes the influencing factors in the corporate charitable donation field with corporate charity as dependent variable and the selection of donation field as independent variable, discusses the weight of the factors affecting the selection decision-making indexes by using AHP-Topsis, constructs the preference model of selection decision-making of corporate charitable donation fields, and solves the problem of how to "donate better".

1.1 Evaluation System in the Charitable Donation Field
The comprehensive evaluation system of the corporate charitable donation fields is the basis of judging the selection of donation fields, which can enhance the effect of corporate donation and improve the donation performance. According to the influencing factors of corporate charitable donation, this paper analyzes the report on China's charitable donation issued by China Charity Alliance in 2017 and 2018 [7-8], and constructs the comprehensive evaluation system of the corporate charitable donation field, as shown in the figure.
in CISSE 2020 mainly consists of three layers: target layer A, criterion layer B and solution layer C. Target layer A mainly consists of corporate charitable donation field, which is the comprehensive benefit of corporate charitable behavior. Criterion layer B represents the four main factors that affect corporate charitable donation, namely, the donation field and enterprise business relevance B1, the social media attention B2, the number of potential customers B3, and the willingness of leaders and employees B4. Solution layer C represents the six fields of corporate charitable donation, namely, education C1, poverty alleviation and community development C2, ecological environment C3, recreation and sports C4, medical treatment C5 and disaster reduction and relief C6. The nature of the enterprise, the business field and the products and services provided are different, thus enterprises can change the actual decision-making in the donation fields.

Figure 1 Structure of Comprehensive Evaluation Level in the Corporate Charitable Donation Field

2. AHP Index Weight

2.1 Establishment of Judgment Matrix

The main body of enterprise decision determines the index of influencing factors, makes pairwise comparison among the elements of each layer, and establishes the order comparison judgment matrix $B$, namely $B = [b_{ij}]_{n \times n}$. In the process of comparison at all levels in the field of charity, the binary method is used to, for the criterion $B_k$, compare $C_i$ and $C_j$ in the donation field according to the data, and their relative importance is used to assign the value to each evaluation index according to the principle of 1~9 scale, as shown in Table 1.

| Scale | Meaning |
|-------|---------|
| 1     | $C_i$ is as important as $C_j$ |
| 3     | $C_i$ is a little more important than $C_j$ |
| 5     | $C_i$ is significantly more important than $C_j$ |
| 7     | $C_i$ is intensively more important than $C_j$ |
| 9     | $C_i$ is extremely more important than $C_j$ |
| 2,4,6,8 | Intermediate value between the two adjacent judgment scales mentioned above |

According to AHP, the comprehensive benefit of corporate charitable donation is regarded as the criterion for target layer A and dominates the factors that affect the comprehensive benefit as the elements $B_1$, $B_2$, $B_3$ and $B_4$ of the next criterion layer. The purpose is to assign the corresponding weights of the influencing factors $B_1$, $B_2$, $B_3$ and $B_4$ according to the relative importance of each factor affecting the comprehensive utility of corporate charity under the premise of maximizing the comprehensive utility of corporate charitable donation. The next step is to figure out which one of elements $B_i$ and $B_j$ is more important for target A. Therefore, it is necessary to assign a certain value to "importance". Judgment Matrix A of the criterion layer to the target layer is established, as shown in Table 2:
Table 2. Judgment Matrix A

|    | A   | B1  | B2  | B3  | B4  |
|----|-----|-----|-----|-----|-----|
| B1 | 1   | b12 | b13 | b14 |
| B2 | b21 | 1   | b23 | b24 |
| B3 | b31 | b32 | 1   | b34 |
| B4 | b41 | b42 | b43 | 1   |

It is necessary to compare and judge whether the data in the judgment matrix satisfies $b_{ij} = 1 / b_{ji} = b_{ik} / b_{jk}$, and whether the comparison matrix has complete consistency. Similarly, the judgment matrix of the solution layer to the criterion layer can be established, as shown in Table 3:

Table 3. Judgment Matrix B-C

|    | B1      | C1        | ......... | C6        | B2      | C1        | ......... | C6        | B3      | C1        | ......... | C6        |
|----|---------|-----------|-----------|-----------|---------|-----------|-----------|-----------|---------|-----------|-----------|-----------|
| C1 | 1       | c16       | ......... | 1         | ......... | c16       | ......... | 1         | ......... | c16       | ......... | 1         |
| ...|         | c46       | ......... | 1         | ......... | c46       | ......... | 1         | ......... | c46       | ......... | 1         |
| C6 | c61     | ......... | 1         | c61       | ......... | 1         | ......... | 1         | ......... | 1         | ......... | 1         |
| B3 |         |           |           |           |         |           |           |           |         |           |           |           |
| C1 | 1       | c16       | ......... | 1         | ......... | c16       | ......... | 1         | ......... | c16       | ......... | 1         |
| ...|         | c46       | ......... | 1         | ......... | c46       | ......... | 1         | ......... | c46       | ......... | 1         |
| C6 | c61     | ......... | 1         | c61       | ......... | 1         | ......... | 1         | ......... | 1         | ......... | 1         |
| B4 |         |           |           |           |         |           |           |           |         |           |           |           |

2.2 Calculation of weight coefficient of the same layer

The judgment matrix is the evaluation data for the pairwise comparison for the previous layer elements, and the hierarchical single ranking is the order in which all the elements of this layer are sorted and shielded against the previous layer elements, with the calculation process as follows:

Normalize a column of the judgment matrix, that is:

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (i, j = 1, 2, \ldots, n) \quad (1)$$

Obtain the sum of the elements of each line, that is:

$$\bar{w}_j = \sum_{i=1}^{n} a_{ij} \quad (i, j = 1, 2, \ldots, n) \quad (2)$$

Formalize $\bar{w}_j$, that is:

$$w'_j = \frac{\bar{w}_j}{\sum_{j=1}^{n} \bar{w}_j} \quad (i, j = 1, 2, \ldots, n) \quad (3)$$

2.3 Consistency test of judgment matrix

Judgment Matrix A is multiplied by the corresponding weight vector to obtain the vector $Aw$.

According to Formula (4), the maximum characteristic value $\lambda_{\max}$ is calculated.

$$\lambda_{\max} = \frac{1}{n} \sum_{j=1}^{n} \frac{(Aw)_j}{w'_j} \quad (4)$$
where, \( n \) is the order of the judgment matrix.

According to Formulas (5) and (6), CR is obtained for consistency test, in which \( R_i \) is the average random consistency index, with the value shown in Table 4.

\[
CR = \frac{C_i}{R_i} 
\]

\[
C_i = \frac{\lambda_{\text{max}} - n}{n - 1} 
\]

When \( CR < 0.1 \), the judgment matrix has satisfactory consistency, otherwise it is necessary to adjust the judgment matrix, analyze Judgment Matrix \( A \) and pass the consistency test.

### Table 4. Average Random Consistency Index

| Order of Judgment Matrix | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
|-------------------------|----|----|----|----|----|----|----|----|----|
| \( R_i \)               | 0  | 0  | 0.58 | 0.90 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

Similarly, the B-C matrix is tested by the above calculation method, and if it passes the consistency test, the optimization matrix of target layer-solution layer analysis can be obtained.

### 3. Comprehensive Evaluation by TOPSIS

The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) is a sequential optimization technique for similarity of ideal objectives. The basic idea is to select a positive ideal solution and a negative ideal solution first, and then find out the best solution that is closest to the positive ideal solution and farthest from the negative ideal solution[10].

#### 3.1 Establishing the weighted normalized decision matrix

The initial matrix \( C=(c_{ij})_{n \times m} \) of the solution layer and the target layer is constructed according to the \( m \)-th evaluation index of the \( n \)-th solution in the evaluation hierarchy chart.

\[
C = \begin{bmatrix}
    c_{11} & c_{12} & \ldots & c_{1m} \\
    c_{21} & c_{22} & \ldots & c_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    c_{n1} & c_{n2} & \ldots & c_{nm}
\end{bmatrix} 
\] (7)

It cannot be compared directly due to the different dimensions of different evaluation indexes. Normalize the initial matrix based on Formula (8) to obtain the normalized matrix \( V' \), \( V'=(v_{ij})_{m \times n} \).

\[
v_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} 
\] (8)

Due to the different degrees of importance of each solution, the entropy weight of each solution should be considered, and the normalized data should be weighted according to Formula (9) to construct the weighted normalized matrix \( V \), where the elements are \( V'_{ij} \) and \( V_{ij} \) respectively.

\[
V_{ij} = w_i \times V'_{ij} \quad (i=1,2,\ldots,n; j=1,2,\ldots,m) 
\] (9)

where, \( i \) represents the evaluation solution No. and \( j \) represents the evaluation index No.

#### 3.2 Comprehensive evaluation

Determine the ideal solution of weighted normalized decision matrix according to Formula (10) and (11).

\[
V^+ = \left\{ \left( \max_{i} V_{ij} \mid j \in J_1 \right), \left( \min_{j} V_{ij} \mid j \in J_2 \right) \mid i = 1,2,\ldots,m \right\} 
\] (10)

\[
V^- = \left\{ \left( \min_{i} V_{ij} \mid j \in J_2 \right), \left( \max_{j} V_{ij} \mid j \in J_1 \right) \mid i = 1,2,\ldots,m \right\} 
\] (11)

where, \( V^+ \) is positive ideal solution and \( V^- \) is negative ideal solution; \( J_1 \) is benefit index set and \( J_2 \) is cost.
Calculate the Euclidean distance between evaluation object and positive & negative ideal solutions according to Formula (12) and Formula (13).

\[ d^+_i = \sqrt{\sum_{j=1}^{m} (V_{ij} - V^+_{ij})^2} \quad (i = 1, 2, \ldots, n) \]  \hspace{1cm} (12)

\[ d^-_i = \sqrt{\sum_{j=1}^{m} (V_{ij} - V^-_{ij})^2} \quad (i = 1, 2, \ldots, n) \]  \hspace{1cm} (13)

where, \( d^+_i \) and \( d^-_i \) is the Euclidean distance between evaluation object and positive & negative ideal solutions; \( V^+_{ij} \) and \( V^-_{ij} \) are the corresponding elements in \( V^+ \) and \( V^- \) respectively.

Calculate the relative approximation of each evaluation object according to Formula (14), and sort from large to small based on the approximation.

\[ C_i = \frac{d^-_i}{d^+_i + d^-_i} \quad (i = 1, 2, \ldots, n), C_i \in (0, 1) \]  \hspace{1cm} (14)

4. Application Case

A green technology real estate development company (hereinafter referred to as Company D) has always been committed to building healthy, comfortable and environmentally friendly green houses. It set up a company foundation in 2011 and won the 8th "China Charity Award". In 2019, it ranked the top 50 in the "Forbes China Charity List", and has donated more than RMB 800 million in poverty alleviation, student aid, disaster relief and cultural undertakings, and funded more than 2000 poverty-stricken students complete their studies. Charity and love accompany the company's progress, and social responsibility has become an important gene of the Company. The six donation fields to be selected by Company D were comprehensively evaluated according to the above method.

Through the questionnaire survey of the relevant deciders of D Company and experts, the respondents were required to pairwise compare and score each criterion in the field of corporate charitable donation field based on the "1-9 Scale Table", and then take the mode of each score to finally obtain the judgment matrix and carry out consistency test. The target layer-criterion layer judgment matrix (judgment matrix A) is shown in Table 5.

| A     | B1 | B2   | B3   | B4   | w   | Index          |
|-------|----|------|------|------|-----|----------------|
| B1    | 1  | 3/7  | 3/5  | 3    | 0.1875 | \( \lambda_{\text{max}}=8.498 \) |
| B2    | 7/3 | 1    | 7/5  | 7    | 0.4375 | C_I=0.0711     |
| B3    | 5/3 | 5/7  | 1    | 5    | 0.3125 | R_P=1.41C_R=0.0505 |
| B4    | 1/3 | 1/7  | 1/5  | 1    | 0.0625 | Consistency pass |

As can be seen from the above table, Company D pays more attention to the social media attention to this field and the number of potential customers of Company D in the living groups of this field during making choices and decisions in the corporate charitable donation field. Similarly, the criterion layer-solution layer judgment matrix (Bi-C judgment matrix) is shown in Tables 6 to 9.

| B1 | C1 | C2 | C3 | C4 | C5 | C6 | w   | Index          |
|----|----|----|----|----|----|----|-----|----------------|
| C1 | 1  | 1/8| 1/4| 1/5| 1/7| 1/6| 0.0740 | \( \lambda_{\text{max}}=5.0145 \) |
| C2 | 8  | 1  | 5  | 4  | 2  | 3  | 0.3268 | C_I=0.0428     |
| C3 | 4  | 1/5| 1   | 1/2| 1/4| 1/3| 0.1073 |               |
| C4 | 5  | 1/4| 2   | 1  | 1/3| 1/2| 0.1077 | R_P=1.02       |
| C5 | 7  | 1/2| 4   | 3  | 1  | 2  | 0.2273 | C_R=0.0127     |
| C6 | 6  | 1/3| 3   | 2  | 1/2| 1  | 0.1569 | Consistency pass |

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Table 7. Judgment Matrix of “Social Media Attention” to Solution Layer (B2-C)

|   | C1  | C2  | C3  | C4  | C5  | C6  | w  | Index   |
|---|-----|-----|-----|-----|-----|-----|----|---------|
| C1| 1   | 2   | 1/2 | 7   | 3   | 1/3 | 0.1787 | $\lambda_{\text{max}}=4.1077$ |
| C2| 1/2 | 1   | 3   | 5   | 4   | 1/4 | 0.3268 | C1=0.0359 |
| C3| 2   | 1/3 | 1   | 8   | 6   | 1/2 | 0.1073 |
| C4| 1/7 | 1/5 | 1/8 | 1   | 1/2 | 1/6 | 0.1077 | Ri=1.02 |
| C5| 1/3 | 1/4 | 1/6 | 2   | 1   | 1/2 | 0.2273 | C_R=0.0399 |
| C6| 3   | 4   | 2   | 6   | 2   | 1   | 0.1569 | Consistency pass |

$\lambda_{\text{max}}$ is the maximum eigenvalue of the matrix.

Table 8. Judgment Matrix of “Large Number of Potential Customers” to Solution Layer (B3-C)

|   | C1  | C2  | C3  | C4  | C5  | C6  | w  | Index   |
|---|-----|-----|-----|-----|-----|-----|----|---------|
| C1| 1   | 2   | 1/2 | 7   | 5   | 3   | 0.2518 | $\lambda_{\text{max}}=4.0145$ |
| C2| 1/2 | 1   | 1/3 | 5   | 4   | 2   | 0.1013 | C1=0.0048 |
| C3| 2   | 3   | 1   | 8   | 7   | 4   | 0.4027 |
| C4| 1/7 | 1/5 | 1/8 | 1   | 1/2 | 1/6 | 0.0455 | R1=1.02 |
| C5| 1/5 | 1/4 | 1/7 | 2   | 1   | 1/2 | 0.0742 | C_R=0.0054 |
| C6| 1/3 | 1/2 | 1/4 | 6   | 2   | 1   | 0.1245 | Consistency pass |

Table 9. Judgment Matrix of “Willingness of Leaders and Employees” to Solution Layer (B4-C)

|   | C1  | C2  | C3  | C4  | C5  | C6  | w  | Index   |
|---|-----|-----|-----|-----|-----|-----|----|---------|
| C1| 1   | 1/2 | 3   | 6   | 2   | 1/3 | 0.1740 | $\lambda_{\text{max}}=4.105$ |
| C2| 2   | 1   | 4   | 7   | 3   | 1/2 | 0.2113 | C1=0.035 |
| C3| 1/3 | 3   | 1   | 2   | 1/2 | 1/5 | 0.1179 |
| C4| 1/6 | 1/7 | 1/8 | 1   | 1/4 | 1/7 | 0.0723 | R1=1.02 |
| C5| 1/2 | 1/3 | 2   | 4   | 1   | 1/3 | 0.1389 | C_R=0.0389 |
| C6| 3   | 2   | 5   | 7   | 3   | 1   | 0.2856 | Consistency pass |

The random consistency ratio $C_R$ of the total ranking at the same level is:

$$C_R = \frac{\sum_{i=1}^{n} (WB_i \times CI)}{\sum_{i=1}^{n} (WB_i \times RI)} = 0.0205 < 0.1 \quad (15)$$

It meets the consistency requirement.

The weight of each donation scheme is shown in Table 10.

Table 10. Weight of Each Donation Scheme

| A  | B1  | B2  | B3  | B4  | Weight of total ranking w |
|----|-----|-----|-----|-----|----------------------------|
| C1 | 0.0740 | 0.1787 | 0.2518 | 0.1740 | 0.1892 |
| C2 | 0.3268 | 0.2453 | 0.1013 | 0.2113 | 0.2165 |
| C3 | 0.1073 | 0.0474 | 0.4027 | 0.1179 | 0.1861 |
| C4 | 0.1077 | 0.0462 | 0.0455 | 0.0723 | 0.0605 |
| C5 | 0.2273 | 0.0746 | 0.0742 | 0.1389 | 0.1094 |
| C6 | 0.1569 | 0.2428 | 0.1245 | 0.2856 | 0.1961 |
| R1 | 0.0428 | 0.0359 | 0.0048 | 0.0350 | 0.0276 |
| C_R| 0.0127 | 0.0399 | 0.0054 | 0.0389 | 0.0200 |
The weighted normalized decision matrix \( V \) was calculated according to Formula (9).

\[
\begin{pmatrix}
0.0139 & 0.0782 & 0.0862 & 0.0109 \\
0.0613 & 0.1073 & 0.0347 & 0.0132 \\
0.0201 & 0.0207 & 0.1379 & 0.0074 \\
0.0202 & 0.0202 & 0.0156 & 0.0045 \\
0.0426 & 0.0326 & 0.0254 & 0.0087 \\
0.0294 & 0.1062 & 0.0426 & 0.0179
\end{pmatrix}
\]  

(16)

Positive and negative ideal solutions of each scheme were calculated according to Formula (10) and Formula (11).

\[
V^+ = \{0.0613, 0.1073, 0.1379, 0.0132\} \\
V^- = \{0.0139, 0.0202, 0.0156, 0.0087\}
\]

The distance between each scheme and positive & negative ideal solutions was calculated according to Formula (12) and Formula (13):

\[
d_1 = 0.004943, \ d_2 = 0.006745, \ d_3 = 0.002169 \\
d_4 = 0.009213, \ d_5 = 0.008446, \ d_6 = 0.003751 \\
d_7 = 0.001347, \ d_8 = 0.002386, \ d_9 = 0.003810 \\
d_{10} = 0.000512, \ d_{11} = 0.000466, \ d_{12} = 0.00297
\]

The relative proximity between each scheme and the positive ideal solution was calculated according to Formula (14).

\[
C_i = \{0.265, 0.603, 0.769, 0.071, 0.106, 0.704\}
\]

The comprehensive superiority of schemes in each donation field is as below: 26.5% for C1 education, 60.3% for C2 poverty alleviation and community development, 76.9% for C3 ecological environment, 7.1% for C4 recreation and sports, 10.6% for C5 medical treatment, and 70.4% for C6 disaster reduction and relief. The quality sequence of donation fields is C3 > C6 > C2 > C1 > C5 > C4, showing C3 ecological environment field is optimal.

The practice of Company D indicates that, the donation field of ecological environment selected by the AHP-TOPSIS Model complies with the corporate's wish, responds to energy conservation and environmental protection goal of the enterprise, and conforms to daily business, and that the model has a good effect.

5. Conclusions

The industry to which an enterprise belongs, the products and services provided, the production characteristics and the needs of external stakeholders are different, so the selection of appropriate donation fields can bring behavioral benefits that meet the needs of enterprises to enterprises and enterprise decision makers. The AHP-TOPSIS preference model that selects decisions based on the fields of corporate charity behaviors can better combine corporate development strategy, match corporate operation means, express the subjective preference of decision-making leadership, and reach the purpose of enhancing the efficiency of corporate charity behaviors and rational application of resources input. In this way, corporate charity behaviors can be planned, scientific and lasting.

Acknowledgments

The present study was supported by the Higher Education and Research of Education Reform in Jiangsu Province (No. 2019JSJG370). The authors acknowledge the assistance offered by Nantong Vocational University.

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