

# Application of *Fuzzy Entropy Theory* to the Green Building Parts Supplier Selection

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## ABSTRACT

Green building and residential industrialization has become the main trend in the development of the real estate industry, The project demand for green building products grow with each passing day, Green building parts suppliers are increased accordingly, How to select reliable suppliers in many vendors has become the key to the success of the project. In order to solve this problem, In this paper, based on the establishment of a green building parts supplier evaluation index system, using fuzzy entropy theory to evaluation index system, and make a case study. The results show that the application of fuzzy entropy theory is to reduce the subjectivity of evaluation, and provide the basis for the selection of suppliers.

**KEYWORDS:** green building, housing industrialization, building parts , fuzzy entropy theory, supplier selection

## INTRODUCTION

The term of housing industrialization was first proposed in 1968 by the Japanese, with the vigorous development of the real estate industry, the construction enterprises in order to reduce the cost of production, improve construction efficiency, enhance the competitive ability, the road is imperative, building industrialization road is imperative, thus the housing industry has been strongly developed. During the same period, With the rising of public awareness for environment protection,

the demand on living environment is also growing, it is necessary to build the building in harmony with nature. In 1969, American architect Ian McHarg of "*Design with Nature*", which marked the official birth of green building. Then, combined with the requirements of the green industrialization residential popularized worldwide. Green industrialized housing, its sign is to establish residential construction standardization system that form combination, energy conservation, emissions reduction and a set of residential department product supply system. Therefore, the evaluation of the green, quality and performance of the building parts is the key to the success of the project, and selection of green building parts suppliers is essential<sup>[1-2]</sup>.

At present, the domestic and foreign research of choice for green building parts suppliers is relatively few. Cengiz Kahraman, Ufuk Cebeci and Ziya Ulukan (2003) use the fuzzy analytic hierarchy process to study the supplier selection<sup>[3]</sup>. Hsu - Shih Shih, Huan - Jyh Shyur (2007) studied the supplier selection by TOPSIS method<sup>[4]</sup>. wang Junwu and Guo Shu wen (2007) use the grey correlation degree for construction supplier selection<sup>[5]</sup>. Peng Pin and li jing (2010) use entropy TOPSIS to study building supplier selection<sup>[6]</sup>. Ruan Lianfa and Chen Jialing (2011) use the fuzzy VIKOR method to carry on the green building supplier selection<sup>[7]</sup>. These methods have a common drawback, that is, are not very well reflect the requirements of green building and building parts. In this paper, through combining the characteristics of green building and housing industry, set up a relatively perfect evaluation index system of the green building parts supplier. Then using the fuzzy entropy theory to evaluate the index system, which has the characteristics of reducing the subjectivity, rating the supplier and comparing various suppliers reasonably and objectively, thereby providing the basis for the construction enterprise to choose the best supplier.

## THE ESTABLISHMENT OF THE EVALUATION INDEX SYSTEM OF THE GREEN BUILDING PARTS SUPPLIER

### The determination of evaluation index

There are a lot of evaluation indicators for the building suppliers, but the evaluation index systems that combination of the green building and construction are less. In this paper, based on the relevant literatures<sup>[8-13]</sup>, combined with the inherent requirements of the housing industry and the characteristics of green building, the evaluation index system (non patent products) of the green building parts supplier is established from four aspects of the product index, the enterprise index, the green index and the cooperation index, as shown in Table 1.

### The establish of selection evaluation set

In most cases, if the experts scoring the underlying indicators when the supplier selection, There would be a slight change in the value of a certain index, the results will be changed to a large extent. Any index score is slightly too large or too small, or there are subtle differences between the scores of the two indicators, eventually will have a big impact on the results of the selection. Therefore, in order to reduce this possibility, make the evaluation more objective and realistic, this article divided the underlying evaluate indexes into five categories, which are good(I), relatively good(II), normal(III), relatively poor(IV) and poor(V)<sup>[14]</sup>.

**Table 1:** Evaluation index system of green building parts supplier

| first-grade indexes                            | second-grade indexes  | third-grade indexes                               |
|--|---|---|
| the product index( $I_P$ )                     | quality( $I_{P1}$ )   | quality management level( $I_{P11}$ )             |
|  |   | Product sample pass rate( $I_{P12}$ )             |
|  |   | The repair rate of return( $I_{P13}$ )            |
|  | Price( $I_{P2}$ )   | quality management standard system( $I_{P14}$ )   |
|  |   | Product performance( $I_{P15}$ )                  |
|  |   | Product price( $I_{P21}$ )                        |
|  | time( $I_{P3}$ )  | Procurement and transportation costs( $I_{P22}$ ) |
|  |   | Installation cost( $I_{P23}$ )                    |
|  |   | Early completion rate( $I_{P31}$ )                |
|  |   | On Time Delivery( $I_{P32}$ )                     |
| professional skill( $I_{E1}$ )                 | Flexible delivery capability( $I_{P33}$ )                               |   |
|  | Contract performance( $I_{E11}$ )                                       |   |
|  | Similar project experience( $I_{E12}$ )                                 |   |
| market position( $I_{E2}$ )                    | quality of personnel( $I_{E13}$ )                                       |   |
|  | Enterprise qualification( $I_{E14}$ )                                   |   |
|  | Enterprise management level( $I_{E15}$ )                                |   |
| the enterprise index( $I_E$ )                  | Financial situation( $I_{E3}$ )   | Market share( $I_{E21}$ )                         |
|  |   | Customer satisfaction( $I_{E22}$ )                |
|  |   | corporate reputation( $I_{E23}$ )                 |
|  | quality of service( $I_{E4}$ )  | Registered capital( $I_{E31}$ )                   |
|  |   | circulating fund( $I_{E32}$ )                     |
|  |   | return on equity( $I_{E33}$ )                     |
|  | innovation ability( $I_{E5}$ )  | asset-liability ratio( $I_{E34}$ )                |
|  |   | Quality of service personnel( $I_{E41}$ )         |
|  |   | Technical level of service personnel( $I_{E42}$ ) |
|  | Environmental protection status( $I_{G1}$ )                             | After sales service quality( $I_{E43}$ )          |
| Innovative capital investment( $I_{E51}$ )     |   |   |
| Innovative personnel input( $I_{E52}$ )        |   |   |
| Product technical innovation rate( $I_{E53}$ ) |   |   |
| Energy consumption level( $I_{G2}$ )           | Investment status of environmental protection funds( $I_{G11}$ )        |   |
|  | Application status of environmental protection technology( $I_{G12}$ )  |   |
|  | Staff environmental awareness( $I_{G13}$ )                              |   |
| environmental effect( $I_{G3}$ )               | Environmental management system certification( $I_{G14}$ )              |   |
|  | Energy consumption per unit of parts( $I_{G21}$ )                       |   |
|  | Material consumption per unit of parts( $I_{G22}$ )                     |   |
| Recovery and utilization( $I_{G4}$ )           | labor consumption per unit of parts( $I_{G23}$ )                        |   |
|  | Other resource consumption( $I_{G24}$ )                                 |   |
|  | Construction noise pollution( $I_{G31}$ )                               |   |
| Cooperation intention( $I_{C1}$ )              | Construction solid waste pollution( $I_{G32}$ )                         |   |
|  | Construction waste gas pollution and waste water pollution( $I_{G33}$ ) |   |
|  | Radionuclide emission( $I_{G34}$ )                                      |   |
| Degree of cooperation( $I_{C2}$ )              | Building parts recovery rate( $I_{G41}$ )                               |   |
|  | Recovery and utilization rate of construction parts( $I_{G42}$ )        |   |
|  | Project cooperation intention( $I_{C11}$ )                              |   |
| the cooperation index( $I_C$ )                 | Long-term cooperation intention( $I_{C12}$ )                            |   |
|  | Corporate culture compatibility( $I_{C21}$ )                            |   |
|  | Enterprise information exchange level( $I_{C22}$ )                      |   |

## The calculation of the index weight based on the fuzzy entropy theory

The size of the index weight directly reflects the Supplier's emphasis on environmental protection in the productive process of construction ministry . Therefore, it is necessary to determine the weight of 1 level indicators, 2 level indicators and 3 level indicators [15-17].

First of all, the experts according to the evaluation rules for each supplier scoring, get the grade membership degree matrix, such as the formula (1);Secondly, based on the theory of entropy, the methods to calculate the weight coefficient of each index are the same but grade membership of normalized vary, the normalization of 3 level indexes and 2 level indexes are shown respectively in the formula (2) and formula (3), first level indexes and 2 class index consistent with a normalization process formula;Finally, the indexes weight are determined as follows:①the calculation of information entropy  $H_{ij}$  based on the data normalization , as shown in equation (4);②The output entropy  $E_{ij}$  is calculated by the information entropy, as shown in formula (5);③according to the maximum output entropy, at this point the contribution of this factor to the system evaluation is the smallest, and the degree of difference  $G_{ij}$  will be calculated base on the formula (6);④obtaining the weights  $w_{ij}$  by the normalization of the difference degrees , shown in equation (7).

$$\begin{pmatrix} R_{i1} \\ R_{i2} \\ \vdots \\ R_{ij} \end{pmatrix} = \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{i1m} \\ r_{i21} & r_{i22} & \cdots & r_{i2m} \\ \vdots & \vdots & & \vdots \\ r_{ij1} & r_{ij2} & \cdots & r_{ijm} \end{pmatrix} \quad (1)$$

$$r_{ijkl} = \frac{x_{ijkl}}{p} \quad (l = 1, 2, 3 \cdots m, 0 \leq r_{ijkl} \leq 1) \quad (2)$$

$$r_{ijk} = \sum_{j=1}^n r_{ijkl} \times w_{ijk} \quad (3)$$

$$H_{ij} = -\sum_{k=1}^m r_{ijk} \ln r_{ijk} \quad (4)$$

$$E_{ij} = -\frac{1}{\ln m} \sum_{k=1}^m r_{ijk} \ln r_{ijk} = \frac{H_{ij}}{\ln m} \quad (5)$$

$$G_{ij} = 1 - E_{ij} \quad (6)$$

$$w_{ij} = \frac{G_{ij}}{\sum_{j=1}^n G_{ij}} \quad (7).$$

## CASE ANALYSIS

**Table 2 Initial evaluation form for supplier A**

| first-grade indexes    | second-grade indexes   | third-grade indexes    | Assessment Grade       |                        |     |    |   |   |   |
|------------------------|------------------------|------------------------|------------------------|------------------------|-----|----|---|---|---|
|                        |                        |                        | I                      | II                     | III | IV | V |   |   |
| <i>I<sub>P</sub></i>   | <i>I<sub>P1</sub></i>  | <i>I<sub>P11</sub></i> | 1                      | 5                      | 3   | 1  | 0 |   |   |
|                        |                        | <i>I<sub>P12</sub></i> | 4                      | 3                      | 1   | 1  | 1 |   |   |
|                        |                        | <i>I<sub>P13</sub></i> | 3                      | 4                      | 2   | 0  | 1 |   |   |
|                        |                        | <i>I<sub>P14</sub></i> | 2                      | 1                      | 4   | 2  | 1 |   |   |
|                        | <i>I<sub>P2</sub></i>  | <i>I<sub>P21</sub></i> | <i>I<sub>P21</sub></i> | 1                      | 3   | 4  | 2 | 0 |   |
|                        |                        |                        | <i>I<sub>P22</sub></i> | 3                      | 3   | 4  | 0 | 0 |   |
|                        |                        | <i>I<sub>P3</sub></i>  | <i>I<sub>P23</sub></i> | <i>I<sub>P23</sub></i> | 4   | 5  | 1 | 0 | 0 |
|                        |                        |                        |                        | <i>I<sub>P31</sub></i> | 2   | 3  | 3 | 1 | 1 |
|                        |                        |                        | <i>I<sub>P32</sub></i> | <i>I<sub>P32</sub></i> | 5   | 3  | 2 | 0 | 0 |
|                        |                        |                        |                        | <i>I<sub>P33</sub></i> | 2   | 4  | 2 | 1 | 1 |
|                        | <i>I<sub>E</sub></i>   | <i>I<sub>E1</sub></i>  | <i>I<sub>E11</sub></i> | 6                      | 1   | 3  | 0 | 0 |   |
|                        |                        |                        | <i>I<sub>E12</sub></i> | 1                      | 0   | 5  | 4 | 0 |   |
|                        |                        |                        | <i>I<sub>E13</sub></i> | 3                      | 3   | 2  | 2 | 0 |   |
|                        |                        |                        | <i>I<sub>E14</sub></i> | 4                      | 3   | 3  | 0 | 0 |   |
| <i>I<sub>E15</sub></i> |                        |                        | 3                      | 4                      | 2   | 1  | 0 |   |   |
| <i>I<sub>E2</sub></i>  |                        | <i>I<sub>E21</sub></i> | <i>I<sub>E21</sub></i> | 2                      | 2   | 5  | 0 | 1 |   |
|                        |                        |                        | <i>I<sub>E22</sub></i> | 3                      | 4   | 3  | 0 | 0 |   |
|                        |                        | <i>I<sub>E23</sub></i> | <i>I<sub>E23</sub></i> | 5                      | 3   | 1  | 1 | 0 |   |
|                        |                        |                        | <i>I<sub>E31</sub></i> | 6                      | 2   | 1  | 0 | 1 |   |
| <i>I<sub>E3</sub></i>  |                        | <i>I<sub>E32</sub></i> | <i>I<sub>E32</sub></i> | 3                      | 2   | 2  | 3 | 0 |   |
|                        |                        |                        | <i>I<sub>E33</sub></i> | 4                      | 2   | 3  | 1 | 0 |   |
|                        |                        | <i>I<sub>E34</sub></i> | <i>I<sub>E34</sub></i> | 3                      | 4   | 0  | 3 | 0 |   |
|                        |                        |                        | <i>I<sub>E41</sub></i> | 1                      | 4   | 5  | 0 | 0 |   |
| <i>I<sub>E4</sub></i>  |                        | <i>I<sub>E42</sub></i> | <i>I<sub>E42</sub></i> | 3                      | 2   | 5  | 0 | 0 |   |
|                        | <i>I<sub>E43</sub></i> |                        | 2                      | 5                      | 0   | 2  | 1 |   |   |
|                        | <i>I<sub>E51</sub></i> | <i>I<sub>E51</sub></i> | 2                      | 3                      | 4   | 1  | 0 |   |   |
|                        |                        | <i>I<sub>E52</sub></i> | 3                      | 4                      | 2   | 1  | 0 |   |   |
| <i>I<sub>G</sub></i>   | <i>I<sub>G1</sub></i>  | <i>I<sub>E53</sub></i> | 2                      | 5                      | 2   | 1  | 0 |   |   |
|                        |                        | <i>I<sub>G11</sub></i> | 3                      | 4                      | 0   | 3  | 0 |   |   |
|                        |                        | <i>I<sub>G12</sub></i> | 0                      | 4                      | 4   | 2  | 0 |   |   |
|                        |                        | <i>I<sub>G13</sub></i> | 1                      | 3                      | 5   | 1  | 0 |   |   |
|                        | <i>I<sub>G2</sub></i>  | <i>I<sub>G14</sub></i> | <i>I<sub>G14</sub></i> | 0                      | 6   | 2  | 2 | 0 |   |
|                        |                        |                        | <i>I<sub>G21</sub></i> | 3                      | 0   | 4  | 3 | 0 |   |
|                        |                        | <i>I<sub>G22</sub></i> | <i>I<sub>G22</sub></i> | 2                      | 1   | 5  | 1 | 1 |   |
|                        |                        |                        | <i>I<sub>G23</sub></i> | 1                      | 3   | 4  | 0 | 2 |   |
|                        |                        |                        | <i>I<sub>G24</sub></i> | 3                      | 2   | 5  | 0 | 0 |   |
|                        |                        |                        | <i>I<sub>G31</sub></i> | 3                      | 1   | 4  | 1 | 1 |   |
|                        | <i>I<sub>G3</sub></i>  | <i>I<sub>G32</sub></i> | <i>I<sub>G32</sub></i> | 1                      | 0   | 5  | 3 | 1 |   |
|                        |                        |                        | <i>I<sub>G33</sub></i> | 3                      | 2   | 5  | 0 | 0 |   |
|                        |                        | <i>I<sub>G34</sub></i> | <i>I<sub>G34</sub></i> | 3                      | 4   | 3  | 0 | 0 |   |
|                        |                        |                        | <i>I<sub>G41</sub></i> | 2                      | 1   | 7  | 0 | 0 |   |
| <i>I<sub>C</sub></i>   | <i>I<sub>G42</sub></i> | <i>I<sub>G42</sub></i> | 1                      | 3                      | 4   | 1  | 1 |   |   |
|                        |                        | <i>I<sub>C11</sub></i> | 5                      | 2                      | 2   | 1  | 0 |   |   |
|                        | <i>I<sub>C1</sub></i>  | <i>I<sub>C12</sub></i> | <i>I<sub>C12</sub></i> | 3                      | 4   | 1  | 2 | 0 |   |
|                        |                        |                        | <i>I<sub>C21</sub></i> | 5                      | 3   | 2  | 0 | 0 |   |
|                        |                        | <i>I<sub>C2</sub></i>  | <i>I<sub>C22</sub></i> | <i>I<sub>C22</sub></i> | 3   | 4  | 2 | 0 | 1 |

With a real estate developer to choose the overall bathroom as an example, there are three suppliers to meet the requirements of the choice, respectively, denote by the letters A, B and C. Examined the levels of various suppliers based on the entropy theory, according to the actual situation of suppliers, invited 10 relevant experts for its scale, and got the initial data of each supplier. Now only gives the specific evaluation process of supplier A, the initial data of supplier A are shown in table 2.

### The calculation of the weight of evaluation index

Through the calculation of the initial evaluation index of supplier A, get 2 level indicators and 1 indicators of grade membership See Table 3 and table 4 respectively, supplier A level of each index weight summary table see table 5. The level of supplier A of each index weight summary table see table 5.

**Table 3: Secondary index level of grade membership**

| $R_{ij}$ | Assessment Grade |        |        |        |        |
|----------|------------------|--------|--------|--------|--------|
|          | I                | II     | III    | IV     | V      |
| $I_{P1}$ | 0.2246           | 0.3849 | 0.2479 | 0.0826 | 0.0599 |
| $I_{P2}$ | 0.3005           | 0.3879 | 0.2682 | 0.0435 | 0.0000 |
| $I_{P3}$ | 0.4113           | 0.3168 | 0.2127 | 0.0296 | 0.0296 |
| $I_{E1}$ | 0.3535           | 0.1749 | 0.3307 | 0.1409 | 0.0000 |
| $I_{E2}$ | 0.3366           | 0.3098 | 0.2923 | 0.0327 | 0.0288 |
| $I_{E3}$ | 0.4172           | 0.2645 | 0.1237 | 0.1624 | 0.0323 |
| $I_{E4}$ | 0.1947           | 0.3529 | 0.3811 | 0.0476 | 0.0238 |
| $I_{E5}$ | 0.2314           | 0.4056 | 0.2629 | 0.1000 | 0.0000 |
| $I_{G1}$ | 0.0921           | 0.4403 | 0.2640 | 0.2037 | 0.0000 |
| $I_{G2}$ | 0.2459           | 0.1428 | 0.4494 | 0.1078 | 0.0541 |
| $I_{G3}$ | 0.2491           | 0.1981 | 0.4289 | 0.0874 | 0.0365 |
| $I_{G4}$ | 0.1809           | 0.1382 | 0.6426 | 0.0191 | 0.0191 |
| $I_{C1}$ | 0.4082           | 0.2918 | 0.1541 | 0.1459 | 0.0000 |
| $I_{C2}$ | 0.4275           | 0.3362 | 0.2000 | 0.0000 | 0.0362 |

**Table 4: First-level indicators level of grade membership**

| $R_i$ | Assessment Grade |        |        |        |        |
|-------|------------------|--------|--------|--------|--------|
|       | I                | II     | III    | IV     | V      |
| $I_P$ | 0.3264           | 0.3608 | 0.2435 | 0.0462 | 0.0231 |
| $I_E$ | 0.2985           | 0.3062 | 0.2868 | 0.0924 | 0.0162 |
| $I_G$ | 0.1811           | 0.2245 | 0.4802 | 0.0912 | 0.0230 |
| $I_C$ | 0.4194           | 0.3176 | 0.1808 | 0.0611 | 0.0211 |

**Table 5:** The level of supplier A of each index weight summary table

| first-grade indexes   | weight | second-grade indexes   | weight | third-grade indexes    | weight | Evaluation value |     |     |     |     |
|-----------------------|--------|------------------------|--------|------------------------|--------|------------------|-----|-----|-----|-----|
|                       |        |                        |        |                        |        | I                | II  | III | IV  | V   |
| <i>I<sub>P</sub></i>  | 0.2588 | <i>I<sub>P1</sub></i>  | 0.2022 | <i>I<sub>P11</sub></i> | 0.4009 | 0.1              | 0.5 | 0.3 | 0.1 | 0   |
|                       |        |                        |        | <i>I<sub>P12</sub></i> | 0.1735 | 0.4              | 0.3 | 0.1 | 0.1 | 0.1 |
|                       |        |                        |        | <i>I<sub>P13</sub></i> | 0.2995 | 0.3              | 0.4 | 0.2 | 0   | 0.1 |
|                       |        |                        |        | <i>I<sub>P14</sub></i> | 0.126  | 0.2              | 0.1 | 0.4 | 0.2 | 0.1 |
|                       |        |                        |        | <i>I<sub>P21</sub></i> | 0.2174 | 0.1              | 0.3 | 0.4 | 0.2 | 0   |
|                       |        | <i>I<sub>P2</sub></i>  | 0.4255 | <i>I<sub>P22</sub></i> | 0.3433 | 0.3              | 0.3 | 0.4 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>P23</sub></i> | 0.4393 | 0.4              | 0.5 | 0.1 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>P31</sub></i> | 0.1271 | 0.2              | 0.3 | 0.3 | 0.1 | 0.1 |
|                       |        |                        |        | <i>I<sub>P32</sub></i> | 0.7044 | 0.5              | 0.3 | 0.2 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>P33</sub></i> | 0.1684 | 0.2              | 0.4 | 0.2 | 0.1 | 0.1 |
|                       |        | <i>I<sub>E1</sub></i>  | 0.1999 | <i>I<sub>E11</sub></i> | 0.2879 | 0.6              | 0.1 | 0.3 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>E12</sub></i> | 0.2696 | 0.1              | 0   | 0.5 | 0.4 | 0   |
|                       |        |                        |        | <i>I<sub>E13</sub></i> | 0.0985 | 0.3              | 0.3 | 0.2 | 0.2 | 0   |
|                       |        |                        |        | <i>I<sub>E14</sub></i> | 0.2107 | 0.4              | 0.3 | 0.3 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>E15</sub></i> | 0.1334 | 0.3              | 0.4 | 0.2 | 0.1 | 0   |
| <i>I<sub>E2</sub></i> | 0.2078 | <i>I<sub>E21</sub></i> | 0.2879 | 0.2                    | 0.2    | 0.5              | 0   | 0.1 |     |     |
|                       |        | <i>I<sub>E22</sub></i> | 0.3854 | 0.3                    | 0.4    | 0.3              | 0   | 0   |     |     |
|                       |        | <i>I<sub>E23</sub></i> | 0.3267 | 0.5                    | 0.3    | 0.1              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>E31</sub></i> | 0.3225 | 0.6                    | 0.2    | 0.1              | 0   | 0.1 |     |     |
|                       |        | <i>I<sub>E32</sub></i> | 0.1507 | 0.3                    | 0.2    | 0.2              | 0.3 | 0   |     |     |
| <i>I<sub>E3</sub></i> | 0.1549 | <i>I<sub>E33</sub></i> | 0.2042 | 0.4                    | 0.2    | 0.3              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>E34</sub></i> | 0.3225 | 0.3                    | 0.4    | 0                | 0.3 | 0   |     |     |
|                       |        | <i>I<sub>E41</sub></i> | 0.4075 | 0.1                    | 0.4    | 0.5              | 0   | 0   |     |     |
|                       |        | <i>I<sub>E42</sub></i> | 0.3547 | 0.3                    | 0.2    | 0.5              | 0   | 0   |     |     |
|                       |        | <i>I<sub>E43</sub></i> | 0.2379 | 0.2                    | 0.5    | 0                | 0.2 | 0.1 |     |     |
| <i>I<sub>E5</sub></i> | 0.2192 | <i>I<sub>E51</sub></i> | 0.3145 | 0.2                    | 0.3    | 0.4              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>E52</sub></i> | 0.3145 | 0.3                    | 0.4    | 0.2              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>E53</sub></i> | 0.371  | 0.2                    | 0.5    | 0.2              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>G11</sub></i> | 0.2393 | 0.3                    | 0.4    | 0                | 0.3 | 0   |     |     |
|                       |        | <i>I<sub>G12</sub></i> | 0.2549 | 0                      | 0.4    | 0.4              | 0.2 | 0   |     |     |
| <i>I<sub>G</sub></i>  | 0.2624 | <i>I<sub>G1</sub></i>  | 0.2488 | <i>I<sub>G13</sub></i> | 0.2028 | 0.1              | 0.3 | 0.5 | 0.1 | 0   |
|                       |        |                        |        | <i>I<sub>G14</sub></i> | 0.303  | 0                | 0.6 | 0.2 | 0.2 | 0   |
|                       |        |                        |        | <i>I<sub>G21</sub></i> | 0.3098 | 0.3              | 0   | 0.4 | 0.3 | 0   |
|                       |        |                        |        | <i>I<sub>G22</sub></i> | 0.1489 | 0.2              | 0.1 | 0.5 | 0.1 | 0.1 |
|                       |        |                        |        | <i>I<sub>G23</sub></i> | 0.1962 | 0.1              | 0.3 | 0.4 | 0   | 0.2 |
|                       |        | <i>I<sub>G3</sub></i>  | 0.1731 | <i>I<sub>G24</sub></i> | 0.3451 | 0.3              | 0.2 | 0.5 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>G31</sub></i> | 0.1102 | 0.3              | 0.1 | 0.4 | 0.1 | 0.1 |
|                       |        |                        |        | <i>I<sub>G32</sub></i> | 0.2547 | 0.1              | 0   | 0.5 | 0.3 | 0.1 |
|                       |        |                        |        | <i>I<sub>G33</sub></i> | 0.3347 | 0.3              | 0.2 | 0.5 | 0   | 0   |
|                       |        |                        |        | <i>I<sub>G34</sub></i> | 0.3005 | 0.3              | 0.4 | 0.3 | 0   | 0   |
| <i>I<sub>G4</sub></i> | 0.4166 | <i>I<sub>G41</sub></i> | 0.8088 | 0.2                    | 0.1    | 0.7              | 0   | 0   |     |     |
|                       |        | <i>I<sub>G42</sub></i> | 0.1912 | 0.1                    | 0.3    | 0.4              | 0.1 | 0.1 |     |     |
|                       |        | <i>I<sub>C11</sub></i> | 0.5412 | 0.5                    | 0.2    | 0.2              | 0.1 | 0   |     |     |
|                       |        | <i>I<sub>C12</sub></i> | 0.4588 | 0.3                    | 0.4    | 0.1              | 0.2 | 0   |     |     |
|                       |        | <i>I<sub>C21</sub></i> | 0.6376 | 0.5                    | 0.3    | 0.2              | 0   | 0   |     |     |
| <i>I<sub>C</sub></i>  | 0.2728 | <i>I<sub>C2</sub></i>  | 0.5812 | 0.3                    | 0.4    | 0.2              | 0   | 0.1 |     |     |
|                       |        | <i>I<sub>C22</sub></i> | 0.3624 | 0.3                    | 0.4    | 0.2              | 0   | 0.1 |     |     |

## Supplier level assessment

Supplier's level evaluation vector  $A$ , its calculation formula is:

$$\square \quad A = W \cdot R = (W_1 \ W_2 \ W_3 \ W_4)^T \cdot (R_1 \ R_2 \ R_3 \ R_4 \ R_5) \quad (8)$$

Formula:  $W$  indicates the 1 level index weight vector;  $R$  is the grade membership of the 1 level indicators (Table 4).

Thus calculated:

- Supplier A is  $A_1 = W \cdot R = (0.3079 \ 0.3020 \ 0.2974 \ 0.0716 \ 0.0211)$
- Supplier B is  $A_2 = W \cdot R = (0.2404 \ 0.3794 \ 0.2926 \ 0.0497 \ 0.0338)$
- Supplier C is  $A_3 = W \cdot R = (0.2350 \ 0.2618 \ 0.2748 \ 0.0983 \ 0.0322)$

## Results analysis

Contrast the level of supplier rating vector can be seen that each supplier sorting should be A, B, C, and grade level I, II, III respectively, thus we can see A supplier for the optimal choice. At the same time, if compared with the level of grade membership of the first level indicators, the product index, the enterprise index, the green index and the cooperation index of grade level of the supplier A are II, II, III, I respectively; the product index, the enterprise index, the green index and the cooperation index of grade level of the supplier B are II, III, III, II respectively; the product index, the enterprise index, the green index and the cooperation index of grade level of the supplier C are III, III, III, II respectively; It is concluded that the supplier still is the best choice. Therefore, using the theory of fuzzy entropy for green building parts supplier selection, the choice of its final result and the middle calculation process can achieve a high degree of match, the influence of subjective factors on the results can sufficiently reduce, well to do the scientific and rational choice.

## CONCLUSION

In this paper, based on the combine features of the green building and the housing industry, establishing the evaluation index system of green building parts supplier. In the specific supplier selection, after experts rated according to actual condition, Using fuzzy entropy theory to analyze the data of expert scoring, calculation process is scientific and rigor, effectively avoid the subjective factors, well do the choice of science, rationality and objectivity; At the same time, fuzzy entropy theory also can divide the level of the supplier, further provide the basis for developers for the selection of suppliers. However, the paper also has deficiencies, one is the establishment of selection index system may still incomplete; Second is in the case analysis only chose three suppliers for analysis, the sample is too small, it affects the applicability of the method to some extent. Future research will further consummate the selection index system, increase the sample size, improve the applicability of the methods, provide more accurate assessment for each supplier.



## REFERENCES

1. Zhang Shengqin, Feng Xuedong. Analysis of the Key Affecting Factors of China's Housing Industrialization Development[J]. *Journal of Engineering Management*, 2015, 29(6):54-58.
2. Zhang Jianguo, Gu Lijing. Development status of green building in china, Challenges and policy recommendations[J]. *Energy of China*, 2012, 34(12):19-24.
3. Kahraman C, Cebeci U, Ulukan Z. Multi-criteria Supplier Selection Using Fuzzy AHP[J]. *Logistics Information Management*, 2003, 16(6):382-394.
4. Shih H S, Shyr H J, Lee E S. An Extension of TOPSIS for Group Decision Making[J]. *Mathematical and Computer Modeling*, 2007, 45:801-813.
5. Wang Junwu, Guo Shuwen. Research of Construction Supplier Selection Model Based on Grey Relevancy [J]. *Journal of Wuhan University of Technology*, 2007, 29 (3) :153-156.
6. Peng Pin, Li Jing. Research on construction supplier selection based on entropy weight TOPSIS[J]. *Journal of Jiangxi University of Science and Technology* , 2010, 31(2):67-69.
7. Ruan Lianfa, Chen Jialing. Green building supplier selection based on fuzzy VIKOR method[J]. *Statistics & Decision*, 2011(21):62-65
8. Charles Kibert. SUSTAINABLECONSTRUCTION:Green Building Design and Delivery, Second Edition[M]. John Wiley & Sons. 2007
9. Zha Jingmin, Song Guanxiu. Green Building Supplier Selection Based on Catastrophe Progression Method[J]. *Journal of Engineering Management*, , 2015, 29(91):43-47.
10. Haselbach L. LEED-NC Guide to engineering: engineers for sustainable construction Manual [M]. DanYinghua, JiangDongqin, Hu Chunyan, translated. Shenyang: Liaoning science and technology publishing house, 2009.
11. Pan HaiZe, Miao Wei, Chen Mengjie, et al. The Application of the LEED in Subway Station Construction Stage[J]. *The Electronic Journal of Geotechnical Engineering*, 2015, (20, 24):11945-11952.
12. Zheng Xiaoyun, Jia Ling. A Study on the Selection of Construction Component Suppliers in the Process of Housing Industrialization[J] *East China Economic Management*, 2013, 27(10):93-97.
13. Hui Yantao. Study of the construction parts greenness assessment system[J]. *Journal of Xi'an University of Architecture & Technology (Natural Science Edition)* , 2007, 39(4):524-528.
14. Zhang Yan. Integrated risk assessment of computer network system based on multi-level fuzzy entropy [J]. *Information and Computer (Theory)*, 2014, ( 9):138.
15. Zhao Guangjin. Research on mine enterprise's safety risk management based on entropy theory [J]. *China Safety Science Journal*, 2012, 22(3):73-78.
16. Pan HaiZe, Chen Mengjie, HeJian, et al. Application of Fuzzy Entropy Theory to Tunnel Leakage Risk[J]. *The Electronic Journal of Geotechnical Engineering*, 2015, (20, 12): 4435-4443.

17. HeJian, Pan HaiZe, Chen Mengjie, et al. Research on Construction Risk of Foundation Pit of Subway Station Based on Rough Set Theory and Catastrophe Progression Method[J]. *The Electronic Journal of Geotechnical Engineering*, 2016, (21, 04):4435-4443.



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