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Research Article

An Entropy Weight-TOPSIS Based Model for Partner Selection of Strategic Alliance of Prefabricated Construction Enterprises

Bin Guo,[1,2] Shengyue Hao,[1] Yi Zhang,[3] Guangmei Cao ,[1] Honghu Gao,[4] and Mingyang Zhang [5]

[1]*School of Economics and Management, Beijing Jiaotong University, Beijing 100044, China*
[2]*Century College, Beijing University of Posts and Telecommunications, Beijing 102101, China*
[3]*School of Logistics, Beijing Wuzi University, Beijing 101149, China*
[4]*School of Management Engineering, Zhengzhou University of Aeronautics, Henan 450046, China*
[5]*School of Economics and Management, Beijing Forestry University, Beijing 100083, China*

Correspondence should be addressed to Guangmei Cao; 1910177971@qq.com

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Selecting the right partner is a key factor for the successful construction of the strategic alliance of prefabricated construction enterprises in China. Based on the summarization of domestic and foreign studies, combined with the characteristics of the strategic alliance of prefabricated construction enterprises, the paper has constructed an evaluation indicator system of the partner selection of the strategic alliance of prefabricated construction enterprises in China. The paper also has conducted an empirical study on the evaluation model of partner selection of the strategic alliance of prefabricated construction enterprises in China by using the method Entropy Weight-TOPSIS. The research results show that the five most influential second-level indicators are commercial housing sales capability, property management capability, commitment of capital, commitment of talents, and product innovation capability. The model constructed in the paper can comprehensively evaluate and select the strategic alliance partners of prefabricated construction enterprises in China.

1. Introduction

At present, Chinese governments at all levels have launched regulatory policies for the development of prefabricated buildings. Continuous regulation has accelerated the differentiation of prefabricated construction enterprises in China. Prefabricated construction enterprises in China have overall ended the model of simple scale expansion and rapid development with huge profits. Getting bigger and stronger has become an important means for prefabricated construction enterprises in China to obtain resources such as land and capital, maintain government relations, avoid risks, and reduce costs. Making strategic alliances has become an important way for prefabricated construction enterprises in China to promote their development. Although the number of alliances has increased significantly, 30%–70% of alliances ended in failure [1, 2]. Studies have found that defects in partner selection are an important reason for failure [3, 4]. Because the prefabricated construction enterprises in China face complex and changeable market environment, selecting the appropriate alliance partner is the key to the construction of strategic alliances for prefabricated construction enterprises in China, which also needs to be further studied.

2. Literature Review

In the aspects of factors affecting the selection of strategic alliance partners, Badaracco [5] held the view that it is necessary to carefully study the compatible values, commitments, and complementary capability of the alternative partners when selecting them as alliance members. Similarly, when choosing partners, enterprises tend to choose familiar or similar enterprises to cooperate. They seek enterprises with rare or valuable resources and hope to learn from partners who are willing to share their expertise. The best partner is the enterprise that can satisfy all these requirements. In the process of choosing partners, influence factors such as the size, management style and corporate culture of the alternative partner, the enterprise's profitability, challenges brought by the previous successful partnerships, other alliances that the alternative partner used to join in, strategy types to reduce cooperation risks, and the current internal capability of the enterprise should be considered. Hutt et al. [6] found that three important factors, trust, commitment, and compatibility, should be considered particularly in partner selection. Sierra [3] suggested using three indicators of compatibility, capability, and commitment to select partners. Shah and Swaminathan [7] also believed that three indicators of complementarity, compatibility, and commitment can be used to select partners.

To sum up, the selection of strategic alliance partners in the present mainly concentrates on the importance of strategic alliance partners and the factors affecting the selection of strategic alliance partners. Studies on the selection of strategic alliance partners of prefabricated construction enterprises in China are still rare. Based on this context, the paper has proposed a selection model of strategic alliance partners of prefabricated construction enterprises in China and analyzed their selection indicators. The paper also uses the method of Entropy Weight-TOPSIS to optimize selection, so as to determine the optimal strategic alliance partners of prefabricated construction enterprises in China.

Based on the selection practice of strategic alliance partners and other related theoretical studies as well as the industry characteristics of the strategic alliance of prefabricated construction enterprises in China, the paper has analyzed the selection criteria of the strategic alliance of the prefabricated construction enterprises from three perspectives.

2.1. Capability. The capability of an enterprise is the ground and guarantee of alliance cooperation. Murray and Siehl [8] emphasized that strategic alliances require partners to have different and complementary contributions in terms of resources, technologies, and capabilities. Anslinger and Jenk [9]further pointed out that the capability of alternative partners should take the availability of key resources, the strategic capability of teamwork, and market demand into consideration.

In summary, an important factor influencing enterprises to select alliance partners is to make up for their lack of capabilities. In general, China has relatively developed economies and high land costs, and households have relatively high requirements for housing quality and property management. The capability of strategic alliance partners of prefabricated construction enterprises in China can be evaluated in terms of the investment planning capability, land obtaining capability, product innovation capability, commercial housing sales capability, and property management capability of enterprises.

2.2. Compatibility. To evaluate the compatibility of alliance partners, the consistency of the background, goals, organization culture, resources, and values of alliance partners can be considered. Sarkar et al. [10] further pointed out that strategy and culture compatibility have a positive impact on the success of strategic alliances, and lack of culture and business compatibility may be the main reason for the failure of partnerships. Enterprises need to avoid cooperation with partners whose strategies, compatibility, character, experience, and motivation are incompatible; otherwise, alliance cooperation cannot be formed [8].

If the compatibility of the alliance partners is not good, the differences and contradictions between partners will increase as soon as the external market and environment change, which can easily lead to the collapse of the alliance. Generally, the compatibility of strategic alliance partners of prefabricated construction enterprises in China is surveyed mainly in terms of strategic goals, corporate culture, management mode, organizational structure, and the amount of commercial housing sales.

2.3. Commitment. Morgan and Hunt [11] believed that commitment means that partners are willing to invest resources and provide help in the alliance and achieve the business goals of partners through fulfilling obligations and taking responsibilities among partners. Sierra [3] held the view that partners must be willing to invest time, energy, and resources to make the alliance successful. When government policies, markets, or technologies change, partners should show a commitment to the capability and willingness to adapt and persist [5]. Moran and Stripp [12] pointed out that partnership depends on the capability of members to maintain their commitments due to the mutual relationship of interests.

Therefore, commitment is an important factor affecting the selection of strategic alliance partners of prefabricated construction enterprises in China. Prefabricated construction enterprises in China have to evaluate whether alternative partners have a sufficient degree of commitment to the alliance. The commitments of strategic alliance partners of prefabricated construction enterprises in China generally include the commitment of capital, land, talents, and knowledge.

3. Modelling Processes

The partner selection of the strategic alliance of prefabricated construction enterprises in China requires not only to construct a complete selection evaluation indicator system but also to determine the weights of indicators. In information theory, entropy can measure the probability of uncertain values of discrete random variables. The higher the order of the indicators is, the lower the information entropy and the greater the indicator weight will be. In this paper, the entropy weight method is adopted to determine the weight of the index.

The method of TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), which is also called an ideal solution, is a sorting method proposed by Hwang and Yoon in 1981 to identify the optimal solution from limited alternatives. The basic logic of TOPSIS is to define the positive ideal solution and negative ideal solution. When a solution is the closest to the positive ideal solution and the farthest to the negative ideal solution, it is determined as the optimal solution. TOPSIS can objectively evaluate various programs under multiple indicators, minimize the influence of human factors, and ensure the authenticity and reliability of evaluation results [13, 14]. Therefore, the paper adopts the method of Entropy Weight-TOPSIS to construct a partner selection model of strategic alliances of prefabricated construction enterprises in China.

3.1. Weights of Indexes

3.1.1. Structure of the Decision Matrix. Suppose evaluation set of multiattribute decision-making problem is $M = (M_1, M_2, \ldots, M_m)$, index set is $N = (N_1, N_2, \ldots, N_n)$, and the jth index's value in the ith alternative is x_{ij}; then, the decision matrix is $X = [x_{ij}]_{m\times n}$.

3.1.2. Normalization of the Decision Matrix. In order to eliminate the influence of index dimension and its variation range on evaluation results, it is necessary to normalize the original matrix to ensure that all the attributes are equivalent and in the same format; then, the normalized decision matrix is

$$\begin{aligned} Y &= \left(y_{ij}\right)_{m\times n}, \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n, \\ y_{ij} &= \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n. \end{aligned} \tag{1}$$

3.1.3. Calculation of the Index's Entropy. According to the definition of entropy, entropy of the jth index is determined by

$$e = -k \sum_{i=1}^{m} y_{ij} \ln\, y_{ij}, \quad 0 \le e \le 1, \tag{2}$$

wherein

$$k = (\ln\, m)^{-1}, \quad (i = 1, 2, \ldots m;\ j = 1, 2, \ldots n). \tag{3}$$

Calculation of the Index's Entropy Weight. Entropy weight of the jth index is determined by

$$w_j = \frac{h_j}{\sum_{j=1}^{n} h_j}, \quad j = 1, 2, \ldots n, \tag{4}$$

wherein

$$h_j = 1 - e_j. \tag{5}$$

3.2. TOPSIS Method

3.2.1. Determination of the Weighted Decision Matrix. The weighted decision matrix is determined by the normalized decision matrix multiplication with weights of indexes and shown by

$$Z = \left(r_{ij}\right)_{m\times n}, \quad i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n, \tag{6}$$

wherein

$$r_{ij} = w_j \cdot y_{ij}, \quad (i = 1, 2, \ldots m;\ j = 1, 2, \ldots n). \tag{7}$$

3.2.2. Determination of the Ideal Solution. The ideal solution is composed of the optimal value of every attribute from the weighted decision matrix, and the negative ideal solution is composed of the worst value of every attribute from the weighted decision matrix, which are shown by

$$\begin{aligned} Z^+ &= z_1^+, z_2^+, \ldots z_n^+, \\ Z^- &= z_1^-, z_2^-, \cdots z_n^-, \end{aligned} \tag{8}$$

wherein

$$\begin{aligned} Z_j^+ &= \max\left\{z_{1j}, z_{2j}, \ldots, z_{mj}\right\}, \\ Z_j^- &= \min\left\{z_{1j}, z_{2j}, \ldots, z_{mj}\right\}, \quad j = 1, 2, \ldots, n. \end{aligned} \tag{9}$$

3.2.3. Calculation of the Distance. The distance of every feasible solution from the ideal solution and the negative ideal solution is calculated, respectively, by (10 and 11).

$$\begin{aligned} D_i^+ &= \left\| z^+ - z_i \right\| \\ &= \sqrt{\sum_{j=1}^{n} \left(z^+ - z_{ij}\right)^2}, \quad i = 1, 2, \ldots m, \end{aligned} \tag{10}$$

$$\begin{aligned} D_i^- &= \left\| z_i - z \right\| \\ &= \sqrt{\sum_{j=1}^{n} \left(z_{ij} - z^-\right)^2}, \quad i = 1, 2, \ldots m. \end{aligned} \tag{11}$$

3.2.4. Calculation of the Relative Degree of Approximation. The relative degree of approximation is determined by

$$B_i = \frac{D_i^-}{D_i^+ + D_i^-}, \quad i = 1, 2, \ldots m. \tag{12}$$

The evaluation object is ranked according to the value of the relative degree of approximation. The bigger the value is, the better the evaluation object is.

3.3. Evaluation Indicators of Partner Selection. According to the previous research results, the evaluation indicators of partner selection of strategic alliances of prefabricated

Table 1: Evaluation indicator system of partner selection of strategic alliances of prefabricated construction enterprises in China.

First-level indicator	Second-level indicator
Capability C_1	Investment planning C_{11} Land acquisition C_{12} Product innovation C_{13} Commercial house sales C_{14} Property management C_{15}
Compatibility C_2	Strategic goal C_{21} Corporate culture C_{22} Management model C_{23} Organizational structure C_{24} Amount of commercial house sales C_{25}
Commitment C_3	Capital C_{31} Land C_{32} Talents C_{33} Knowledge C_{34}

Table 2: The indicators' evaluation values of six alternative partners.

First-level indicator	Second-level indicator	P1	P2	P3	P4	P5	P6
Capability C_1	Investment planning C_{11}	7.4	7.6	8.3	8.6	7.8	8.2
	Land acquisition C_{12}	8.3	8.8	8.2	9.1	7.9	7.6
	Product innovation C_{13}	7.6	8.1	7.6	8.4	8.8	9.0
	Commercial house sales C_{14}	5.8	6.7	7.4	6.5	7.0	5.9
	Property management C_{15}	8.8	8.5	7.2	9.4	7.8	8.6
Compatibility C_2	Strategic goal C_{21}	8.5	8.2	9.0	7.8	8.3	9.1
	Corporate culture C_{22}	8.8	8.1	8.5	7.8	8.2	8.8
	Management model C_{23}	9.1	8.7	8.6	9.2	8.5	8.9
	Organizational structure C_{24}	7.8	8.7	8.5	7.8	7.6	7.9
	Amount of commercial house sales C_{25}	7.7	8.9	7.6	8.5	7.8	8.4
Commitment C_3	Capital C_{31}	6.9	6.7	7.6	8.3	7.8	7.4
	Land C_{32}	8.7	7.5	7.9	7.4	8.2	7.6
	Talents C_{33}	7.8	7.4	7.2	6.7	8.3	7.5
	Knowledge C_{34}	7.8	8.6	9.4	9.1	8.6	8.8

construction enterprises in China are constructed as shown in Table 1.

4. Model Evaluation and Results

4.1. Research Object Selection and Data Collection. The paper has selected JA real estate enterprise (hereinafter referred to as JA Company) as the research sample to verify the feasibility and rationality of the method of partner selection of strategic alliances of prefabricated construction enterprises in China.

JA Company is one of the earliest real estate companies engaged in real estate development in China. JA Company has formed strategic alliances with many prefabricated construction enterprises. JA Company selects elites from various departments within the company to form a selection team of strategic alliance partners to be responsible for the selection of strategic partners, which covers all aspects of the enterprise from design to sales, as well as all internal management and operation aspects of the enterprise. Based on the previously studied selection indicator system of strategic alliances of prefabricated construction enterprises in China, the paper has finally selected a total of 6 prefabricated construction enterprises in China as alternative partners, which are P1, P2, P3, P4, P5, and P6, respectively, and conducted empirical analysis on the selection method of strategic alliances of prefabricated construction enterprises in China.

According to the evaluation indicator system (shown in Table 1), the indicators' evaluation values of those six alternative partners are shown in Table 2.

4.2. Evaluation Results

4.2.1. Calculation of the Entropy Weight and the Ideal Solution. The entropy weights are calculated according to equations (2)–(5). The positive ideal value and the negative ideal value are obtained by equations (6)–(9). The results are shown in Table 3.

4.2.2. Determination of Evaluation Ranks. The distance of every feasible solution from the positive ideal solution and the negative ideal solution is obtained according to (10) and (11). The relative degree of approximation is determined according to (12). The queuing indicator value of six alternative partners could be ranked by the relative degree of approximation and is shown in Table 4.

Table 3: The entropy weights and the ideal solutions of six alternative partners.

First-level indicator	Second-level indicator	Entropy weights	Positive ideal value	Negative ideal value
Capability C_1	Investment planning C_{11}	0.0515	0.0093	0.0080
	Land acquisition C_{12}	0.0699	0.0128	0.0107
	Product innovation C_{13}	0.0808	0.0147	0.0124
	Commercial house sales C_{14}	0.1416	0.0267	0.0209
	Property management C_{15}	0.1358	0.0254	0.0194
Compatibility C_2	Strategic goal C_{21}	0.0535	0.0096	0.0082
	Corporate culture C_{22}	0.0365	0.0064	0.0057
	Management model C_{23}	0.0158	0.0027	0.0025
	Organizational structure C_{24}	0.0467	0.0084	0.0073
	Amount of commercial house sales C_{25}	0.0646	0.0118	0.0100
Commitment C_3	Capital C_{31}	0.0979	0.0182	0.0147
	Land C_{32}	0.0612	0.0113	0.0096
	Talents C_{33}	0.0821	0.0152	0.0123
	Knowledge C_{34}	0.0621	0.0112	0.0093

Table 4: The distance, the relative degree of approximation, and evaluation ranks.

Alternative partners	Positive ideal solution	Negative ideal solution	Relative degree of approximation	Evaluation ranks
P1	0.0078	0.0053	0.4021	5
P2	0.0059	0.0058	0.4927	2
P3	0.0073	0.0068	0.4836	3
P4	0.0051	0.0081	0.6117	1
P5	0.0100	0.0065	0.3931	6
P6	0.0069	0.0055	0.4411	4

5. Discussion

According to the evaluation results and based on the weights of each indicator, it can be concluded that the weights of capability, compatibility, and commitment are 47.96%, 21.70%, and 30.33%, respectively. The findings of evaluation results indicate that capability has the greatest influence on the partner selection of strategic alliance of prefabricated construction enterprises. The five most influential second-level indicators are commercial housing sales capability(14.16%), property management capability (13.58%), commitment of capital (9.79%), commitment of talents (8.21%), and product innovation capability (8.08%).

The outcomes of applying the TOPSIS approach revealed the ranking of the alternative partners. The bigger the relative degree of approximation is, the better the partner is. As can be seen from Table 4, evaluation ranks of six alternative partners are as follows: P4 >P2 > P3> P6> P1> P5. The results obtained by this method are consistent with reality. P4, P2, and P3 are the top three alternative partners, and P4 is the most promising alternative partner. In total, the method of Entropy Weight-TOPSIS provides an opportunity for partner selection of strategic alliance of prefabricated construction enterprises.

6. Conclusion and Limitations

The paper has constructed an evaluation indicator system of partner selection of strategic alliances of prefabricated construction enterprises in China, which is composed of 3 first-level indicators of capability, compatibility, and commitment and 14 second-level indicators. The paper has also constructed an evaluation model of partner selection of strategic alliances of prefabricated construction enterprises in China based on the method of Entropy Weight-TOPSIS. Six alternative partners of JA Company have been selected as research samples to conduct empirical study. The model constructed in the paper can comprehensively evaluate and select the strategic alliance partners of prefabricated construction enterprises in China.

A drawback sometimes arises with Entropy Weight-TOPSIS which is associated with the relative nature of the judgments involved. Here, changing the set of alternatives changes the ranking of all alternatives. Further research studies can focus on designing more reasonable evaluation methods.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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