Research on Fuzzy Comprehensive Evaluation of Small and Medium Enterprises Cluster Innovation Capability

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Abstract: We know that Innovation plays a crucial role in sustainable development for small and medium enterprises (SMEs) cluster. This paper applies a multi-criteria methodology to SMEs cluster innovation capability appraisal, known as the analytic hierarchy process (AHP). This methodology is especially useful when there is partial information and/or qualitative variables are used. Firstly, this paper defines the SMEs cluster innovation capability, and analyzes its composition. Secondly, it establishes three levels index system. Finally, fuzzy comprehensive evaluation method is used to evaluate the innovation capability of small and medium enterprises cluster.

Keywords: SMEs, Enterprises cluster, Innovation capability, Fuzzy comprehensive evaluation

1 Introduction

Clusters are geographic concentrations of interconnected enterprises and institutions in a particular field (Porter, 1998). There is a growing literature linking the dynamism of small and medium enterprises to their location within industrial clusters. Clusters are thought to promote innovation through frequent interactions and information flows (Antonelli, 1999). Enterprises of the cluster exchange and create knowledge through face-to-face interactions and with the creation of common languages and institutions. Cluster might greatly foster innovation any time it involves a large share of tacit knowledge (Nonaka and Takeuchi, 1995). The geographic concentration of suppliers and customers provides firms with shorter feedback loops for innovations (Boari, 2001). Cluster could usefully be thought of as a reduced-NIS (national innovation system), in which the most essential and functional system elements help stimulate the emergence of specific kinds of innovation in various segments of national economy (OECD, 2001).

Evaluation is basically understood as a set of systematic tools through which actions and processes can be measured and assessed. In the SMEs cluster innovation systems, there are a number of system defects which affect the innovation behavior and performance. The evaluation of cluster innovation capability is significant because the press can help us find the system defects. Evaluation and monitoring is warranted for measuring the efficiency and effectiveness of cluster policies. Accordingly, cluster policy can be made to counter the defects based on the evaluation result.

A fuzzy comprehensive evaluation method has been set out in this paper and has proven to be especially useful in the following instances: when data is only partially available; when using qualitative variables; or when using quantitative variables which are inaccessible to the professional and their quantification cannot therefore be deduced. This situation presents difficulties when applying conventional appraisal methods. The application of the analytic hierarchy process to the field of enterprises cluster evaluation is an advance with respect to previous studies on the application of multi-criteria methods in which only quantitative variables have been used.

2 Designing of Index System

The innovation capability of SMEs Cluster is the ability to create knowledge, share knowledge and apply knowledge, which is an integration ability composed of knowledge innovation, technology innovation and products innovation carried out by SMEs collaborative networks and the support institutions (universities, public research institutions, knowledge intermediaries, etc.). The Formation and improvement of SMEs cluster innovation capability depends on the knowledge resource allocation.
and coordination efficiency based on knowledge diffusion, learning mechanism and knowledge management within SMEs cluster. At the same time, the innovation capability of SMEs Cluster is affected by technical environment, culture, social development level and so on. As shown in Table 1, this paper constructs the evaluation index system. There are three layers and ten evaluating indexes in the system. SMEs cluster innovation capability(U) is the goal layer; the first index layer consist of three indexes: enterprise technological innovation capability(U1), cluster network innovation capability (U2) and innovation environment factor (U3); The second index layer is the overall segments of the first index layer, including all the Uij.

### Table 1  The Comprehensive Evaluation Index System of SEMs Cluster Innovation Capability

<table>
<thead>
<tr>
<th>SMEs cluster innovation capability (U)</th>
<th>First Index Layer</th>
<th>Second Index Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enterprise technological innovation capability (U1)</td>
<td>Core enterprises technological innovation capability (u11)</td>
</tr>
<tr>
<td></td>
<td>Cluster network innovation capability (U2)</td>
<td>Joint innovation capability (u21)</td>
</tr>
<tr>
<td></td>
<td>Innovation environment factors (U3)</td>
<td>Knowledge diffusion capacity (u24)</td>
</tr>
</tbody>
</table>

3  Fuzzy Evaluation Model

Given the factors set of SMEs cluster’s innovation capability which will be evaluated is U. Based on different attributes of the factors, U is divided into u1, u2,…, um, namely, there are m subsets. The evaluation comprises three categories and 10 factors.

\[ U = \{ U_1(\text{Enterprise technological innovation capability}), U_2(\text{Cluster network innovation capability}), U_3(\text{Innovation environment factors})\} = \{u_{11}, u_{12}, \ldots, u_{34}\} \]

The steps are described as follows:

3.1 The weight for the evaluation factors

\[ A = \{A_1, A_2, A_3\} = \{a_{11}, a_{12}, \ldots, a_{34}\} \]

The weight is calculated by using Fuzzy Relation Equation and Method of Weighted Mean[^6][^7].

3.2 Confirm the degree of subjection of indexes

When innovation capability of SMEs cluster is evaluated, it must be evaluated together by experts, decision-makers and entrepreneurs based on the comment set. The result is the degree of subjection shown as matrix RB:

\[ \text{RB}_i = (r_{ij})_{2 \times 5}, \text{RB}_2 = (r_{ij})_{4 \times 5}, \text{RB}_3 = (r_{ij})_{4 \times 5}, r_{ij} = d_{ij}/d, \]

\[ d_{ij} \] is the number of persons who gives j level on the i-th index, d is the number of all the experts.

3.3 The evaluation result

\[ V = \{V_1(\text{higher}), V_2(\text{high}), V_3(\text{middle}), V_4(\text{low}), V_5(\text{lower})\} \]

3.4 The result of the second level fuzzy comprehensive evolution

We can deduce the integrated evaluating vector of u according to the theory of fuzzy:

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3.5 The result of the first level fuzzy comprehensive evaluation

The fuzzy evaluating matrix of $U$ is $R^*$:

$$R^* = \begin{bmatrix} B_1 & B_2 & B_3 \end{bmatrix} = \begin{bmatrix} b_{i1} & b_{i2} & \cdots & b_{im} \\ b_{i1} & b_{i2} & \cdots & b_{im} \\ \vdots & \vdots & \ddots & \vdots \\ b_{i1} & b_{i2} & \cdots & b_{im} \end{bmatrix}$$

Every $u_i$ as one part of $U$, it reflects some attributes of $U$. We can distribute the weight according to their essentiality, namely, $A^*=(a_1, a_2, a_3)$. So we can get the integrated evaluating vector:

$$B^* = A^* \cdot R^* = (b_1, b_2, \ldots, b_m)$$

According to the principle of degree of maximum membership degree, given $B_k = \max(b_1, b_2, \ldots, b_m)$, the integrated evaluation vector is $B_k$.

4 Application Example

With the mathematical model and methods mentioned above, we evaluate innovation capability of one SMEs cluster. According to the index system, we use the evaluating model.

4.1 Subject degree of index

The expert group is made up of five domain experts, three decision makers and four entrepreneurs. The group evaluates every index in term of comment set, hence we can get $R_{B_1}$:

$$R_{B_1} = \begin{bmatrix} 0.20 & 0.30 & 0.20 & 0.15 & 0.15 \\ 0.25 & 0.35 & 0.15 & 0.15 & 0.10 \end{bmatrix}$$

$$R_{B_2} = \begin{bmatrix} 0.25 & 0.25 & 0.15 & 0.20 & 0.15 \\ 0.25 & 0.30 & 0.15 & 0.20 & 0.10 \\ 0.20 & 0.25 & 0.25 & 0.15 & 0.15 \end{bmatrix}, \quad R_{B_3} = \begin{bmatrix} 0.20 & 0.20 & 0.25 & 0.25 & 0.10 \\ 0.25 & 0.35 & 0.15 & 0.15 & 0.10 \\ 0.30 & 0.30 & 0.25 & 0.10 & 0.05 \\ 0.20 & 0.40 & 0.20 & 0.15 & 0.05 \end{bmatrix}$$

4.2 Index weight

The domain experts confirmed the index weight. We have verified the consistency of judging matrix. The consistency is eligible, we receive integrated judging matrix, and calculate the weights follows: $A^*=(0.58, 0.31, 0.11)$, $A_1=(0.75, 0.25)$, $A_2=(0.44, 0.24, 0.2, 0.12)$, $A_3=(0.4, 0.3, 0.17, 0.13)$.

4.3 Fuzzy evaluation

$$R^* = \begin{bmatrix} A_1 \cdot R_{B_1} \\ A_2 \cdot R_{B_2} \\ A_3 \cdot R_{B_3} \end{bmatrix} = \begin{bmatrix} 0.203 & 0.313 & 0.188 & 0.150 & 0.138 \\ 0.240 & 0.268 & 0.178 & 0.184 & 0.132 \\ 0.232 & 0.288 & 0.213 & 0.181 & 0.082 \end{bmatrix}$$

$$B^* = A^* \cdot R^* = \begin{bmatrix} 0.203 & 0.313 & 0.188 & 0.150 & 0.138 \\ 0.240 & 0.268 & 0.178 & 0.184 & 0.132 \\ 0.232 & 0.288 & 0.213 & 0.181 & 0.082 \end{bmatrix}$$

$B^*=(0.218, 0.296, 0.187, 0.164, 0.130)$

Then do normalization processing, $B^*=(0.22, 0.30, 0.19, 0.16, 0.13)$,

$B_k=\max(0.22, 0.30, 0.19, 0.16, 0.13)=0.30$

4.4 Result
According to the principle of maximum membership degree, the evaluating level the SMEs cluster innovation capability is $V_2$, namely, higher.

5 Conclusion

Evaluating the innovation capability of small and medium enterprises cluster is an important part for developing cluster policy. Building scientific evaluation systems, making appropriate evaluation factors and attaching corresponding weight to them are of vital importance in evaluating correctly the innovation capability of SMEs cluster. We evaluate the innovation capability by using the three level comprehensive evaluation of fuzzy mathematics. A multi-criteria methodology, namely AHP, has been set out in this paper and has proven to be especially useful. The application of the method in SMEs cluster appraisal is an improvement over previous work, in which both quantitative and qualitative variables are used where only partial information is available.

References