Research on the Evaluation of the Growth Level of SMEs Clustering Based on Digitalization

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Abstract. SME clusters play an important role in promoting regional economy. How to evaluate the growth level of SMEs clusters around has become the focus of scholars' research. This paper constructs the evaluation system of SME cluster growth level from the macro, meso and micro levels, establishes an evaluation model of SME cluster growth level based on digitalization by using fuzzy comprehensive evaluation, chromatography analysis and MATLAB program, and applies this model to the SME cluster in Jinan City, and finally evaluates its high level of cluster growth.

Keywords: digitization · SME cluster · clustering growth level · assessment index system · evaluation model

1 Introduction

Since the 1990s, China's SME clusters have developed very rapidly, and have become an important organizational form and carrier of China's regional economic development. Clustering development has fundamentally changed the survival environment and even the survival mode of SMEs, which is an inevitable choice to enhance the competitiveness of SMEs. SME clusters play a prominent role in promoting regional economy and even the economic development and prosperity of a country [1]. How to evaluate the cluster growth level of small and medium-sized technology enterprises has become the focus of relevant scholars. Through research, this paper has created an evaluation index system for the growth level of small and medium-sized technology enterprises clusters that is suitable for the national conditions and can reflect a certain degree of industrial agglomeration. It has also established an evaluation model for the growth level of small and medium-sized technology enterprises clusters by using analytic hierarchy process (AHP), fuzzy overall evaluation method and MATLAB program, Provide a quantitative tool to scientifically evaluate the growth level of small and medium-sized technology enterprises.

X. Yuan et al. (Eds.): ICEKIM 2023, AHCS 13, pp. 283–291, 2023.
https://doi.org/10.2991/978-94-6463-172-2_31

2 Evaluation Index System for the Growth Level of Small and Medium-Sized Technological Enterprises

To establish the model, it is necessary to study and find appropriate indicators that can scientifically evaluate the growth level of small and medium-sized technology enterprises. The selection of indicators must reflect the factors that affect the growth of small and medium-sized enterprises and the extent of their impact. This paper uses the foreign research level theory of SME clusters for reference, and analyzes the influencing factors of SME cluster growth from three levels: macro, meso and micro environment [2, 3].

2.1 Macro Environment

The macro environment proposed in this paper refers to some elements that have no direct effect on enterprise activities but often have potential impact on enterprise decision-making, mainly including technology, economy, culture, political and legal aspects related to the entire industrial environment, forming a multi-level system consisting of economic development level, scientific and technological level, social and cultural atmosphere, legal system construction and other levels. The macro environment is composed of the most influential environmental factors that penetrate into the behaviors of various environmental subjects in an environmental region. The role of social environment on environmental subject is extensive, and its impact involves the behavior of each subject in the environment [4].

2.2 Meso Environment

First, whether the cluster can attract and provide specialized input factors, including talents, intermediate inputs and more enterprises [5].

Second, whether the cluster can provide quasi public goods services, including specialized infrastructure, education projects, information platforms, trade shows, etc. Quasi public goods services are the most difficult to provide when a cluster grows, and it is difficult for a single private enterprise to provide such services, which can only be provided by local governments or industry associations.

Third, how about the information service quality and efficiency of the cluster. The rapid growth of relevant market, technology, or other specialized information in enterprises or organizations in the cluster enables employees in the cluster to use this information quickly and cheaply to improve production efficiency.

Fourth, how is the cluster related to the outside world. If a cluster can be embedded in the global value chain, it can drive products to go abroad.

2.3 Micro Environment

First of all, factors such as trust and sanctions within the cluster have increasingly affected the development of the cluster. Without trust, it is difficult to cooperate; Without sanctions, it is difficult to eliminate “violators”. The competitiveness of clusters also comes from conscious joint action [6].

Secondly, the product quality and marketing of the cluster can be improved through complementarity. Complementarity between products within the group can be seen everywhere, not limited to product complementation, but also from service delivery to product design, logistics, after-sales service, etc.

Thirdly, whether the cluster can have a good competitive environment is also very important. Fierce competition can eliminate the inferior, thus producing better cost performance. Especially when a powerful new competitor appears, the imitation effect will make the innovative ideas pass forward, backward and horizontally.

Fourth, the enterprises in the cluster are good at learning and continuous innovation, which is conducive to the development of the cluster [7].

Fifth, if new enterprises are easy to establish in the cluster, the cluster can have sustained vitality. On the contrary, if innovation is suppressed and the creation of new enterprises is hindered, the normal metabolism of the cluster will be affected, which is not conducive to its growth.

Through the above research, combined with the environmental factors of SME's own growth and clustered growth, this paper has created a set of indicators reflecting the level of SME's clustered growth from the macro, meso and micro levels, as shown in Table 1.

Table 1. Evaluation system of SME cluster growth level

Target Layer	Criterion Layer	Indicator Layer
Growth level of SME clustering	Macro condition indicators U_1	Advantages in economic resources U_{11}
		Advantages in technical resources U_{12}
		Policy advantages U_{13}
		Cultural advantages U_{14}
	Medium level condition indicator U_2	Industrial concentration U_{21}
		Support from local governments U_{22}
		Perfection of social supporting service system U_{23}
		Industrial relevance U_{24}
		Perfection of infrastructure communication conditions U_{25}
		The speed of knowledge diffusion U_{26}
	Micro condition indicators U_3	Local embeddedness U_{31}
		Mobility of high-quality talents in the region U_{32}
		The ease of creating new enterprises in the region U_{33}
		Degree of competition and cooperation among enterprises U_{34}

It can be seen from the evaluation index system of SME cluster growth level that this system has the characteristics of large element quantity and fuzziness. It will be difficult to evaluate with the first or second level comprehensive evaluation model. If only single level fuzzy comprehensive evaluation is adopted, when there are many factors, it is difficult to assign appropriate weights and consider the level of factors. However, the two-level fuzzy comprehensive evaluation cannot give consideration to both the weight distribution and the fuzziness of factors. Therefore, this paper adopts three levels of fuzzy comprehensive evaluation, that is, each factor is divided into several levels according to its degree, and all factors are divided into several types according to their nature. When judging, the first level of fuzzy comprehensive evaluation is carried out according to each grade of each factor, and the evaluation result of single factor is obtained; Then, the second level fuzzy comprehensive evaluation is carried out according to each factor of each category, and the evaluation results of the first category of factors are obtained; Finally, we will make a comprehensive evaluation among all kinds to get the evaluation results of all factors. In this way, we can not only deal with the fuzziness of factors, but also avoid the difficulty of weight distribution caused by many factors [8].

3 Evaluation Model of Small and Medium-Sized Enterprises Cluster Growth Level

3.1 Evaluation Method

This paper adopts the fuzzy comprehensive evaluation method combining Fuzzy Mathematics, AHP (Analytical Hierarchy Process) and MATLAB to establish the evaluation model of the growth level of SMEs cluster. This method has the following characteristics: (1) It includes multiple indicators that reflect different aspects of things; (2) These indicators are often of different degrees, and it is impossible to have a unified factor of the same variable; (3) It is required to make a unified judgment result on the evaluated things [9].

3.2 Evaluation Steps

1) Build factor set

All 14 elements that determine the characteristics of SME clustering level will form a factor set U, and each factor in the set will be divided into 3 categories according to its nature, namely, $U = \{U_1, U_2, U_3\}$, $U_1 = \{U_{11}, U_{12}, \ldots, U_{14}\}$; $U_2 = \{U_{21}, U_{22}, \ldots, U_{26}\}$; $U_3 = \{U_{31}, U_{32}, U_{33}, U_{34}\}$.

Each factor U_{ij} (i = 1, 2, 3) is the number of criteria layer factors, (j = 1,… n, n is the number of indicator layer factors) is divided into p grades according to its degree. For simplicity, this paper takes p = 5.

Therefore, there are $U_{ij} = \{u_{ij1}, u_{ij2}, \cdots, u_{ij5}\}$.

U_{ij} is called the grade set of the jth factor in the class i factor. For example, the factor of "industrial concentration U_{21}" can be divided into five levels: "strong, strong, general, weak and weak". In order to simplify the calculation, the levels of each factor are

arranged according to the principle of consistency of the trend affecting the evaluation object, that is, they are arranged in the order of making the growth level of SMEs cluster from high to low [10].

2) Building weight sets

The membership of the k-th grade of this factor U_{ij} to this factor is given by the expert group. The specific evaluation process is as follows: a group of judges (such as scientific and technological experts, management experts, economic experts, etc., generally 20–50 people) will grade the factors investigated, and then make statistics on the evaluation results. a_{ijk} is the quotient obtained by dividing the number of experts participating in the evaluation by the total number of people participating in the evaluation. Therefore, the grade weight set of factors is $A_{ij} = (a_{ij1}, a_{ij2}, \cdots, a_{ijn})$.

For multi-level comprehensive evaluation, it is also necessary to assign corresponding weights according to the importance of each factor in each level, that is, the confirmed membership of each factor to the importance of the upper level factors. The first level factor weight set is $A_i = (a_{i1}, a_{i2}, \cdots, a_{in})$.

The AHP method is used to determine the weight set in this model. The basic steps are: on the basis of the factor hierarchy division model, the relative comparison between two factors at the same level is carried out using the 1–9 scale, and the judgment matrix is constructed. This process is completed by the expert group. The relative importance of the elements of the same level evaluated by a certain superior element can be calculated by the characteristic value of the matrix with MATLAB program. For example, calculate the weight of U_{3j} to U_3, The calculation process is as follows:

A = [1 4 2 5;1 1/4 1 1 2;1 1/2 1 1 4;1/5 1/2 1/4 1] %Input comparison judgment matrix A;
a = eig(A) %Find all the eigenvalues of A;
[X, D] = eig(A) %Find all eigenvectors and diagonal matrices of A;
a1 = a (1,:) %Take the largest characteristic value from all characteristic values of A;
a2 = X (:,1) %Take the eigenvector corresponding to the maximum eigenvalue from all eigenvectors of A;
a3 = ones(1,3) %Construct a 1 whose elements are all 1 × 4 Matrix;
a4 = a3 * a2%Sum all elements in a2;
w = 1/a4 * a2%Find the ranking vector of matrix A;
ci = (a1–3)/2%Find out the consistency index;
cr = ci/0.58%Calculate the consistency ratio

In this paper, senior managers of SMEs, experts from science and technology bureaus and universities are invited to score, and according to the above steps, the weight set of each level is calculated. The results are as follows:

First level A = (0.3028,0.5210,0.1762)
Second level A_1 = (0.4326,0.2781,0.1534,0.1359)
A_2 = (0.3120,0.2976,0.1263,0.1012,0.0924,0.1717)
A_3 = (0.4942,0.2633,0.1099,0.1326)

3) Establish evaluation set

The size of the evaluation set can be set according to the actual degree of segmentation

and the amount of calculation. Here we set the degree of SME clustering to k levels, $k = 5$,The recognition is divided into five grades: low, slightly low, medium, high and high.

The recognition is divided into five grades: low, slightly low, medium, high and high. $V = \{V_1, V_2, \ldots, V_5\}$, V is the evaluation set.

4) First level fuzzy comprehensive evaluation

The influence of each factor on the comprehensive index can be given through the comprehensive evaluation of its various grades. In this way, it is not necessary to determine the specific state of the factor in advance when conducting single factor evaluation. No matter how fuzzy the factor is, this method can effectively reflect the influence of the factor. If the evaluation is conducted according to the k-th grade of the jth factor in class i, and the membership degree of the evaluation object to element in the evaluation set is r_{ijkl} (k = 1, 2, 3, 4, 5; l = 1, 2, 3, 4, 5, 6), then the factor's grade evaluation matrix is $R_{ij} = (r_{ijkl})_{1\times5}$.

5) Two level fuzzy comprehensive evaluation

The second level fuzzy comprehensive evaluation is based on all factors of the factor subset. Obviously, U_{ij} single factor evaluation set should be a first level fuzzy comprehensive evaluation set, so U_{ij} single factor evaluation matrix is $R_i = (b_{ijl})_{1\times5} = (r_{ijl})_{1\times5}$.

Therefore, the set of secondary fuzzy comprehensive evaluation is $B_i = A_i \odot R_i = (b_{i1}, \cdots, b_{i5})$.

6) Three level fuzzy comprehensive evaluation

That is to say, fuzzy comprehensive evaluation is carried out among various types. Obviously, the single factor evaluation set of type i should be a two-level fuzzy comprehensive evaluation set, so U single factor evaluation matrix is $R_i = (b_{il})3 \times 5 = (r_{il})3 \times 5$.

If the weight of factor type i is, then the weight set of factor set U is $A = (a_1, a_2, a_3)$.

Therefore, the three-level fuzzy comprehensive evaluation set is $B = A \odot R = (b_1, \cdots, b_5)$.

4 Evaluation on the Growth Level of Small and Medium-Sized Enterprises in Jinan

4.1 Data Collection

In order to scientifically evaluate the actual situation of SME cluster growth in Jinan, this paper designs a questionnaire on SME cluster growth level based on the established "SME cluster growth level evaluation index system", and conducts an empirical study on SME cluster growth level in Jinan. The survey mainly includes 14 indicators, including economic resource advantages, technological resource advantages and national policy advantages. The questionnaire requires respondents to make a 5-level judgment according to the actual situation of the enterprise and the actual situation of each indicator element. For example, 1 represents the low level of the factor, and 5 represents the high level of the factor. In May 2022, a large-scale survey was conducted in Jinan Hi tech Development Zone and other small and medium-sized enterprises gathering areas. A

total of 200 questionnaires were distributed, 167 were recovered, and 136 were valid. The recovery rate and effective rate were 83.5% and 81.4% respectively, which met the requirements of the technical method of social questionnaire. The survey collected 14×136 data, and the first level fuzzy comprehensive evaluation matrix (single factor evaluation matrix) is obtained by statistical sorting of these data. The calculation process is Formula (1)–(3).

$$R_1 = \begin{pmatrix} 0.033 & 0.086 & 0.289 & 0.462 & 0.130 \\ 0.020 & 0.057 & 0.314 & 0.408 & 0.201 \\ 0.059 & 0.066 & 0.348 & 0.379 & 0.148 \\ 0.023 & 0.143 & 0.313 & 0.471 & 0.104 \end{pmatrix} \tag{1}$$

$$R_2 = \begin{pmatrix} 0.087 & 0.245 & 0.263 & 0.317 & 0.088 \\ 0.024 & 0.079 & 0.205 & 0.467 & 0.225 \\ 0.035 & 0.087 & 0.359 & 0.298 & 0.221 \\ 0.029 & 0.250 & 0.276 & 0.372 & 0.073 \\ 0.028 & 0.040 & 0.269 & 0.451 & 0.212 \\ 0.041 & 0.157 & 0.433 & 0.275 & 0.094 \end{pmatrix} \tag{2}$$

$$R_3 = \begin{pmatrix} 0.002 & 0.076 & 0.382 & 0.364 & 0.176 \\ 0.030 & 0.231 & 0.289 & 0.350 & 0.010 \\ 0.104 & 0.058 & 0.271 & 0.378 & 0.189 \\ 0.041 & 0.155 & 0.450 & 0.322 & 0.032 \end{pmatrix} \tag{3}$$

4.2 Evaluation Process

According to the above steps, the calculation process is shown in Formula (4)–(9).

$$B_1 = A_1 \odot R_1 = (0.032, 0.083, 0.309, 0.435, 0.149) \tag{4}$$

$$B_2 = A_2 \odot R_2 = (0.051, 0.167, 0.316, 0.402, 0.165) \tag{5}$$

$$B_3 = A_3 \odot R_3 = (0.026, 0.125, 0.300, 0.356, 0.114) \tag{6}$$

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{pmatrix} 0.032 & 0.083 & 0.309 & 0.435 & 0.149 \\ 0.051 & 0.167 & 0.316 & 0.402 & 0.165 \\ 0.026 & 0.125 & 0.300 & 0.356 & 0.114 \end{pmatrix} \tag{7}$$

$$B = A \odot R = (0.041, 0.735, 0.311, 0.404, 0.151) \tag{8}$$

$$V = BV^T = B(1, 2, 3, 4, 5)^T \tag{9}$$

$$\begin{pmatrix} 0.041 & 0.735 & 0.311 & 0.404 & 0.151 \end{pmatrix} \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{pmatrix} = 4.465$$

Therefore, it can be evaluated that the growth level of SMEs in Jinan is relatively high.

5 Conclusions

At present, the evaluation of the degree of industrial clusters is mostly a preliminary conclusion obtained through qualitative analysis, lacking quantitative basis. However, there is no mature research achievements to apply to the determination of the growth level of enterprise clusters, which is the bottleneck to push the industrial cluster theory to a deeper level through empirical research. Based on the research on the influencing factors of SME cluster growth, this paper establishes an evaluation index system that reflects the level of SME cluster growth from the macro, meso and micro levels, and establishes an evaluation model of small and medium-sized enterprises cluster growth level based on digitalization by using the methods of AHP, fuzzy overall evaluation method and MATLAB program, The model is used to quantitatively evaluate the growth level of SMEs in Jinan. It can be seen that the growth level of small and medium-sized enterprises in Jinan is relatively high and the development status is good. This model can provide reference and help for other regions to evaluate the growth of SME clusters.

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