An entropy method-based index system for the competiveness of industrial cluster – a case study on the typical clusters in Zhejiang province in China

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Abstract

Basing on the previous research results, this study constructed an index system for the competiveness of the industrial cluster using analytic network process (ANP) method. Moreover, it employed the entropy method in objective assignment method to assign weights to the indexes and conducted empirical analysis by exampling the typical clusters in Zhejiang province. The results showed that the industrial concentration degree, specialization degree (location quotient), and Herfindahl-Hirschman index (HHI) took relatively high proportions in the indexes concerning the competitiveness of industrial clusters. This study also drawn an important conclusion, namely, high industrial concentration degree was conducive to improve cluster competitiveness and reduce cluster risk, while lower industrial concentration degree facilitated the formation of high overall cluster competitiveness.

Keywords: ANP, entropy method, Industrial cluster competitiveness

1 Introduction

In the context of economic globalization, industrial clusters have become remarkable regional trends, which have had a huge role in promoting economic development in both developed and developing countries. However, industrial clusters will likely lead to a recession or even crash of the entire regional economy if there are problems. So the correct evaluation of the competitiveness of industrial clusters has become an important issue. To comprehensively evaluate the competiveness of industrial cluster, it is needed to construct a scientific evaluation index system by treating industrial cluster as a network and comprehendsively analysing the competitiveness and relationships of all network layers.

2 The theoretical framework of the indexes for evaluating the industrial cluster competiveness

2.1 THE BASIS FOR CONSTRUCTING EVALUATION INDEXES FOR INDUSTRIAL CLUSTER COMPETIVENESS

This study built an evaluation index system for the industrial cluster competitiveness from the following aspects in reference with previous research results:

1) Using ANP method, index system was divided into the target layer, criterion layer, and index layer in turn. Meanwhile, in reference with related study results concerning industrial cluster network structure, the criterion layer of the index system was further decomposed into enterprise network, support network, and social network [1].
2) The core index for the competitiveness of enterprise network included five aggregation indexes, namely, industrial concentration, spatial Gini coefficient, EG index, location entropy, and two indexes reflecting the dynamic variations of cluster enterprises, namely, the derivation degree and innovation degree of enterprises.
3) The indexes for support network employed three indexes that were closely correlated with the cluster development, namely, public service platform construction, professional market perfection, and industry association service. The three indexes were scientifically evaluable using corresponding quantitative indexes through conversion [2].
4) Social network index was mainly selected according to the cluster embed ability of the social capital and social network in the social network structure of industrial cluster. The core indexes in the two factors, including entrepreneurship and social capital, were used for qualitative analysis. In real application, the two indexes could be subjectively analysed and evaluated using expert advice method and Delphi method [3].

2.2 THE INDEX SYSTEM FOR EVALUATING THE COMPETITIVENESS OF INDUSTRIAL CLUSTERS

According to the construction principle and basis above and the network structure characteristics of industrial cluster, this study constructed the index system for evaluating the competitiveness of industrial clusters, as shown in Table 1.

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TABLE 1 The index system for evaluating the competitiveness of industrial clusters

Target layer A	Criterion layer B	Index layer X		
		Index code	Index	Index connotation
The competiveness of industrial cluster A	The competiveness of enterprise network B1	X1	Industrial concentration	The total output of a cluster / the output of a industry in national level or in a high-level regional range
		X2	Spatial Gini coefficient	The distribution equilibrium degree of industrial space of cluster: G=∑N(si-xi) 2
		X3	EG index	Cluster scale and the cluster aggregation degree bearing regional differences γ=[Gi-(1-∑rxj2)Hi]/[(1-∑rxj2)(1- Hi)]
		X4	Cluster specialization degree (location quotient)	The ratio of cluster output in regional total output/ the ratio of provincial industrial output in total provincial output
		X5	The enterprise aggregation in a cluster(HHI)	The quadratic sum of ratio of the output of the leading enterprises in the cluster to the total output of the cluster
		X6	Derivation degree of cluster enterprises	The investment of fixed assets /the total output of cluster
		X7	The creative degree of cluster enterprises	The output of new products/ total output of cluster
	B2 The competiveness of supporting network B2	X8	Supporting degree of public service platform and	Total assets of service platform/the number of service enterprises
		X9	The perfection degree of professional market	Total market turnover/ number of market stands
		X10	The service level of industrial associations	Number of member enterprises/ number of industrial associations
	The competiveness of social network B3	X11	Entrepreneurship	The innovation consciousness of entrepreneur
		X12	Social relationship	The monopoly of social assets

3 The entropy method-based calculation method for index weight

At present, index weigh is mainly determined using subjective and objective assignment methods. In light of that the indexes of the competiveness of industrial cluster were constructed using the ANP in subjective assignment method, the weight of these indexes were determined using the entropy method in objective assignment method. Moreover, five typical clusters in Zhejiang Province was employed for empirical analysis.

3.1 INTRODUCTION OF THE PRINCIPLE OF ENTROPY METHOD

"Entropy" was sourced from the Greek and represents the variant capacity. Clausius pointed out that, since entropy was similar with energy and were both functions of state; the two concepts should also be similar in word form. In reference with the German expression of energy, namely, energy, Clausius noted the entropy as entropie. Chinese physicist Hu Gangfu firstly translated the entrpoie into Chinese word as "熵" by adding the word "商" with a "火" on the left in 1923 in view of the ratio of entropy energy variations to temperature [4].

In mathematics, entropy signifies the uncertainty of a situation or problem. In 1950s, American proposed the information theory. In this theory, entropy was directly treated as the uncertainty of the state of the signals sent from an information source and signified the information-sending ability of non-information source. Since then, entropy spread to non thermodynamic field in a new look. Subsequently, entropy was widely and rapidly applied into the fields of economy, city planning, decision analysis, artificial intelligence, and philosophy etc. In project evaluation, it is always needed to take account of the importance of each evaluation index. One of most direct and convenient methods to represent the importance is assigning weight to each index (weight coefficient). The research conclusion regarding the entropy theory above suggests that the accuracy and reliability of decision are dependent on the information amount grasped by decision maker in the decision process. Meanwhile, entropy serves as an ideal scale for the evaluation on different decision processes and case-handling effects [4,5].

3.2 THE BASIC STEPS FOR CALCULATING THE INDEX WEIGHTS USING ENTROPY METHOD

First, selecting positive or negative indexes as the evaluation indexes according to the research object and calculating y_{ij} according to standard equation, where, the treatment equation for positive index is calculated by (the larger the index, the better)

$$y_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} . \quad (1)$$

The treatment equation for the negative index is given by (the smaller the index, the better)

$$y_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}. \quad (2)$$

Secondly, calculating the entropy of evaluation indexes: in an evaluation issue containing m evaluation indexes and n evaluation objects, the entropy H_j of the *j*-th evaluation index is defined as:

$$H_j = -k\sum_{i=1}^{n} f_{ij} \ln f_{ij} \quad (j=1,2,...,m), \quad (3)$$

where, $f_{ij}=y_{ij}/\sum iy_{ij}$ (i=1,2,…,n), k=1/lnn. Moreover, it is assumed that when $f_{ij}=0$, $f_{ij}\ln f_{ij}=0$. The smaller the entropy of an index, the more useful the information provided by this index to the decision maker.

Thirdly, calculating the entropy weights of evaluation indexes: in the evaluation issue of (m,n), the entropy weight of the *j*-th index is defined as:

$$w(j) = \frac{1-H(j)}{m-\sum_{j=1}^{m} H(j)}. \quad (4)$$

4 An empirical analysis on the weights of the competiveness indexes of five typical clusters in Zhejiang Province

4.1 STANDARDIZATION OF THE ORIGINAL INDEXES FOR THE COMPETIVENESS OF INDUSTRIAL CLUSTERS

In this study, the original data of 5 typical industrial clusters in Zhejiang Province in 2011 were obtained from the data submitting platform for the key industrial clusters in Zhejiang province. Moreover, according to the data in the statistical yearbook of Zhejiang Province, the competitiveness indexes of the industrial clusters were calculated. In view of the competitiveness of support network showed little influences and was hard to be quantitatively analyzed as well, this study merely analyzed the weight of enterprise network competiveness of the industrial clusters using entropy method. The X1 to X5 of competiveness of enterprise network were calculated using the original data of the five industrial clusters on the "data submitting platform for the key industrial clusters in Zhejiang province" of the Zhejiang Province Economic and Information Commission in 2011. The calculation process was neglected in this study [6]. Table 2 shows the calculation results. Table 3 show the calculation results in Table 2 after being treated by the standardization equation of entropy method.

TABLE 2 The original data of the enterprise network competiveness of five industrial clusters in Zhejiang province

Criterion layer	Index code	Index	Typical industrial clusters				
			Shaoxing textile cluster	Haining leather cluster	Cixi household appliances cluster	Yongkang hardware cluster	Yueqing industrial electrical cluster
The competiveness enterprise network B1	X1	Industrial concentration	0.290	0.146	0.065	0.089	0.101
	X2	Spatial Gini coefficien	0.022	0.016	0.001	0.006	0.007
	X3	EG index	0.0210	0.0049	-0.0035	0.0036	0.0046
	X4	Location quotient	2.13	7.47	3.32	14.78	5.39
	X5	The aggregation degree of cluster enterprises (HHI)	0.0014	0.0112	0.0045	0.0024	0.0024
	X6	The derivation degree of cluster enterprises	0.038	0.022	0.050	0.067	0.124
	X7	The innovation degree of cluster enterprises	0.206	0.308	0.197	0.178	0.258

Data source: The "data submitting platform for the key industrial clusters in Zhejiang province" of the Zhejiang Province Economic and Information Commission.

TABLE 3 The standard data of the enterprise network competiveness of five industrial clusters in Zhejiang Province

Criterion layer	Index code	Index	Typical industrial clusters				
			Shaoxing textile cluster	Haining leather cluster	Cixi household appliances cluster	Yongkang hardware cluster	Yueqing industrial electrical cluster
The competiveness enterprise network B1	X1	Industrial concentration	1	0.36	0	0.107	0.16
	X2	Spatial Gini coefficien	1	0.762	0	0.238	0.286
	X3	EG index	1	0.343	0	0.290	0.331
	X4	Location quotient	0	0.422	0.094	1	0.258
	X5	The aggregation degree of cluster enterprises (HHI)	0	1	0.316	0.102	0.102
	X6	The derivation degree of cluster enterprises	0.157	0	0.275	0.441	1
	X7	The innovation degree of cluster enterprises	0.215	1	0.146	0	0.615

4.2 THE CALCULATION AND ANALYSIS ON THE COMPETIVENESS OF INDUSTRIAL CLUSTERS

Index weights were calculated according to the basic steps of entropy method, as shown in Table 4 (the calculation process is omitted).

TABLE 4 The index weight of the competiveness of the typical clusters in Zhejiang Provinces

Warning index X_J		Weight(W_J)
X_1	Industrial concentration	0.167
X_2	Spatial Gini coefficient	0.114
X_3	EG index	0.111
X_4	Location quotient	0.150
X_5	The aggregation degree of cluster enterprises (HHI)	0.190
X_6	The derivation degree of cluster enterprises	0.131
X_7	The innovation degree of cluster enterprises	0.138

According to weights, the indexes were sequenced as X5> X1> X4> X7> X6> X2> X3. This result suggests that the industrial concentration degree, specialization degree (location quotient), and HHI index take relatively high proportions in indexes of enterprise network competiveness. Moreover, industrial concentration, spatial Gini coefficient, and EG index are internally correlated. Gini coefficient and EG index take small proportions since they are used to detect the regional competiveness degree of a cluster.

By comparing the economic benefit indexes of the five typical clusters in Zhejiang Province in Table 5, it is found that Shaoxing textile cluster and Yueqing industrial cluster show higher economic benefits. Comparison on the network competiveness of the five clusters reveals that the two clusters above have high industrial concentration degree but low specification level and enterprise concentration degree. This result suggests that high industrial concentration degree is conductive to improve the cluster competiveness, while low industrial concentration degree means the low competiveness among enterprises and the high overall cluster competiveness formed thereby [7].

TABLE 5 The economic benefit indexes of the five typical clusters in Zhejiang Province

Indexes / Clusters	Labor Productivity(ten thousand Yuan per person)	Per capita profit rate (%)
Shaoxing textile cluster	76.38	2.96
Haining leather cluster	29.29	1.30
Cixi household appliances cluster	30.38	1.05
Yongkang hardware cluster	27.06	2.16
Yueqing industrial electrical cluster	42.1	2.89

Data source: The data submitting platform for the key industrial clusters in Zhejiang province

5 Conclusion and discussion

This study preliminarily attempts to quantitatively evaluate the competitiveness of industrial clusters. As for the large and complex industrial cluster network system, some factors are hard to be quantified and dynamic data are difficult to be collected [8]; limited by time, paper length, and objective conditions, this study merely empirically analyzed the typical industry clusters in Zhejiang Province. This determines the limitation of this study.

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