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Evaluation on Ecological Environment of Scientific and Technological Innovation Talents in China

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Abstract

Ecological environment of scientific and technological innovation talent directly affects the configuration of resources and economic development. This paper constructs ecological environment evaluation index system of regional scientific and technological innovation talent, by using entropy value method to empowerment of the evaluation index, and set pair analysis method to analyze Chinese scientific and technological innovation talent ecological environment comprehensively in 2014. The study shows that: (1) Economic development, social security, science and education and talent, scientific and technological innovation entrepreneurship evaluation results show that the eastern region > central region > western region;(2) In the ecological environment comprehensive evaluation of scientific and technological innovation talents, eastern region > central region> western region;(3)Social security and scientific and technological innovation entrepreneurship conditions are the main factors.

Key words: Scientific and technological innovation talents, evaluation, set pair analysis

1. Introduction

Talent is the most valuable resource and wealth in today's society. Under the background of economic globalization, each country or region has been swept up in the battle for global talents resources. The success or failure of talent resources in the global competition depends on whether the country provides a good ecological environment on growth and career development for all kinds of talents. Therefore, in essence, the talent competition is the competition of talent ecological environment. Implementation of independent innovation is the breakthrough of development bottleneck in China especially in the west region, and important strategies to realize economic and social development. The key to improve the ability of independent innovation is the cultivation of innovative talents in science and technology. And good talent ecological environment is the cradle of scientific and technological innovation talents, and it has positive significance to the stock of scientific and technological innovation talents scale and improvement of quality and ability.

Many scholars studied talent ecological environment and obtained the valuable conclusions. Through sorting them can be found: on the research content, the research mainly took in Shandong province in Chinese eastern region (Xu, 2013; Liu, 2014), Zhejiang province (Zhong, 2014) and the western region (Hao, 2015), etc. as examples, carried on the empirical analysis and put forward the corresponding suggestion; On the research methods, this research mainly used analytic hierarchy process and data envelopment analysis (Zhou, 2013) and fuzzy comprehensive evaluation method (Xu, 2014) and other methods; In addition, there are some scholars to research talents evaluation index system of ecological environment (Li, 2006; Ruan, 2011), make analysis and evaluation. The above research provides reference for talent ecological environment evaluation, but also has some limitations: on the research methods, scholars mainly adopt qualitative description or analytic hierarchy process, the subjectivity is stronger and conclusion has certain one-sidedness; On the object of study, the scholars mainly focused on evaluation of the developed eastern region, and paid less attention to the central and western regions. From the perspective of input and output, the paper builds ecological environment evaluation index system of scientific and technological innovation talents, uses set pair analysis model to evaluate regional scientific and technological innovation talent ecological environment, objectively measures regional scientific and technological innovation talent ecological environment difference. It has positive meaning to promote the healthy development of talent and the scientific and technological innovation.

2. Evaluation index system

2.1 Indexes design principles

(1)Strong practicability: the selected indexes should be concise and easy to understand, basis on scientific theory, and accepted easily by the public. At the same time, the establishment of the index system should associate with evaluation model to facilitate application.

(2) High information integration: the number of the selected indexes should be simple, but the information it contains should be highly integrated, can reflect ecological environment of scientific and technological innovation talents in China in temporal and spatial scales.

(3) Data is easy to obtain: the selected indexes of quantitative data should be accessible to ensure operability.

2. 2 Evaluation index system

Talent ecological environment is social system that composed of many complex factors. According to lewin's psychology field theory, on the basis of the master on the connotation of talent ecological environment, in the light of the principle of comprehensive, scientific, dynamic, feasibility, it constructs ecological environment evaluation index system of scientific and technological innovation talents in the western region. It includes three steps: first, on the basis of relevant literature on scientific and technological innovation talent ecological environment evaluation research, choose the relevant influence factors; second, invite ten experts on talent, make three rounds of consultation with Delphi method, and get 18 impact factors finally, set these factors as three-level index, then classified as four dimensions and be designed as secondary indexes; third, again consult with ten experts and adjust the evaluation index. So with the completion of three steps, it constructs evaluation index system of ecological environment of scientific and technological innovation talents, which includes 4 secondary indexes, 18 tertiary quantitative indicators.

Table 1 Ecological environment evaluation index system of scientific and technological innovation talent and weights

Grade 1 indicators	Grade 2 indicators	Weights	Grade 3 indicators	Code	Weights
Ecological environment of Scientific and technological innovation talents evaluation index system	Economic development	0.316	Per capita GDP (Yuan)	X11	0.141
			GDP growth rate (%)	X12	0.268
			Average wage on-the-job worker (RMB one hundred million)	X13	0.171
			Urban per capita disposable income/ Yuan	X14	0.420
	Social security	0.205	Health care expenditure($one hundred million)	X21	0.206
			Social security and employment expenditure (one hundred million Yuan)	X22	0.261
			Environmental protection	X23	0.183

		expenditure ($one hundred million)		
		Number of days above secondary in major cities (days)	X24	0.201
		Green coverage rate in built up area (%)	X25	0.149
Science and education and talent	0.301	Spending on science and technology (one hundred million Yuan)	X31	0.150
		Education expenditure ($one hundred million)	X32	0.230
		Number of institutions of higher learning (a)	X33	0.187
		Average number of students in higher education institutions of per thousand population (people)	X34	0.183
		Number of Research and development institutions(a)	X35	0.189
		Number of researchers (people)	X36	0.061
Scientific and technological innovation and entrepreneurship	0.178	R&D project numbers(item)	X41	0.211
		Effective number of invention patents(item)	X42	0.491
		Number of new product development (item)	X43	0.298

3. Research methods

3. 1 Set pair analysis evaluation method

Based on current research, the paper established set pair analysis static evaluation model.

(1) Build evaluation matrix

Assume that n objects to be evaluated constitute the set $E=\{e_1, e_2, \ldots, e_n\}$ and e_n is the n th. Every object to be evaluated has m evaluation indices $F=\{f_1, f_2, \ldots, f_m\}$, and f_m refers to the m th index. The value of the evaluation index is recorded as d_{ij} （i=1，2，…，n；

j=1，2，…，m）. Then in line with set pair analysis method, a multi-target evaluation matrix Q is got:

$$Q=\begin{bmatrix} d_{11} & d_{12} & \dots & d_{1n} \\ d_{21} & d_{22} & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ d_{m1} & d_{m2} & \dots & d_{mn} \end{bmatrix} \quad (1)$$

Based on matrix Q, the evaluation indices are compared and chosen to decide the optimal evaluation set $U=[d_{u1},d_{u2},...,d_{un}]^T$ made up of optimal evaluation indices in all evaluation plans. In a similar way, the worst evaluation set is obtained as $V=[d_{v1},d_{v2},...,d_{vn}]^T$. d_{uj} is the evaluation index value ranking c_{pk} in the optimal evaluation set $U=[d_{u1},d_{u2},...,d_{un}]^T$, which is the optimal one during $[v_p,u_p]$ in the matrix Q, while d_{vj} is the evaluation index value ranking c_{pk} in the worst evaluation set $V=[d_{v1},d_{v2},...,d_{vn}]^T$, which is the worst one during $[v_p,u_p]$ in the matrix Q.

By comparing the evaluation index value w_p and the corresponding index value d_{uj} in the optimal set $U=[d_{u1},d_{u2},...,d_{un}]^T$, the similar degree matrix A of objects and the set $[U,V]$ without weights can be got:

$$A=\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \quad (2)$$

By comparing the evaluation index value w_p and the corresponding index value d_{vj} in the worst set $V=[d_{v1},d_{v2},...,d_{vn}]^T$, the opposite degree matrix A of objects and the set $[U,V]$ without weights can be got:

$$B=\begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \dots & \dots & \dots & \dots \\ b_{m1} & b_{m2} & \dots & b_{mn} \end{bmatrix} \quad (3)$$

In the matrix A and B, $\begin{cases} a_{pk} = \dfrac{u_p v_p}{d_{pk}(u_p + v_p)} \\ c_{pk} = \dfrac{d_{pk}}{u_p + v_p} \end{cases}$, with b_{ij} as the similar degree and the opposite degree of the object evaluated f_m and the set $[U, V]$.

If d_{ij} imposes positive influence on the evaluation result,

$$\begin{cases} a_{ij} = \dfrac{d_{ij}}{d_{uj} + d_{vj}} \\ b_{ij} = \dfrac{d_{uj} d_{vj}}{d_{ij}(d_{uj} + d_{vj})} \end{cases} \quad (4)$$

If d_{ij} imposes negative influence on the evaluation result,

$$\begin{cases} a_{ij} = \dfrac{d_{uj} d_{vj}}{d_{ij}(d_{uj} + d_{vj})} \\ b_{ij} = \dfrac{d_{ij}}{d_{uj} + d_{vj}} \end{cases} \quad (5)$$

(2) Building the evaluation model

Combined weights of all evaluation indices $W = (w_1, w_2, ..., w_m)$ and the similar degree matrix A, the weighted similar degree matrix A_w of the objects and the set $[U, V]$ can be obtained as follows:

$$A_w = W \times A = (w_1 \quad w_2 \dots \ w_m) \times \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} = (a_1, a_2, ..., a_n) \quad (6)$$

Similarly, the weighted opposite degree matrix B_w of the objects and the set $[U, V]$ can be obtained as follows:

$$B_w = W \times B = (w_1 \quad w_2 \ \dots \ w_m) \times \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \dots & \dots & \dots & \dots \\ b_{m1} & b_{m2} & \dots & b_{mn} \end{bmatrix} = (b_1, b_2, ..., b_n) \quad (7)$$

a_j in the formula (6) is the similar degree of the j th object and the set $[U, V]$ and b_j in the formula (7) the opposite degree of the j th object and the set $[U, V]$.

(3) Calculating the relative closeness degree

The relative closeness degree r_j of the j th object and the optimal evaluation set $U = [d_{u1}, d_{u2}, ..., d_{un}]^T$ is calculated as:

$$r_j = \frac{a_j}{a_j + b_j} \tag{8}$$

Then the relative closeness degree matrix R of the objects evaluated can be got: $R = (r_1, r_2, ..., r_m)$, r_j refers to the closeness degree of the object evaluated and the optimal evaluation set $U = \left(d_{u1} \;\; d_{u2} \; ... \; d_{un}\right)^T$, which means the bigger r_j is, the closer the object is to the optimal plan. In this way, the plan ranks higher among all plans evaluated.

(4) In multi-layer comprehensive evaluation, stepwise computation by layer can be adopted. Namely, the initial model is used into multiple layers, and every layer uses the evaluation result of the next layer till that of the highest layer. Finally, based on all this, the comprehensive evaluation can be made.

3.2 Determine evaluation index weight

The entropy evaluation method is to assess the practical value in line with the information loaded by the evaluation index to ensure the credibility of the evaluation result. Thus, this paper used entropy method to evaluate index weighting.

Information entropy can be used to describe the degree of disorder of the system and to quantitatively judge the direction of evolution of the urban ecosystem. When n indicators have been evaluated in m years, let E_i be the information entropy of evaluation indicator i, then it can be can be derived thus:

$$E_i = -1/\ln(m)\sum_{i=1}^{n}\frac{q_{ij}}{q_j}\ln(\frac{q_{ij}}{q_j}) \qquad (i=1,\ 2,\ \ldots\ldots, n;\ \ j=1,\ 2,\ \ldots\ldots,\ m) \tag{9}$$

In Formula (9), q_{ij} is the standardized value of initial data of the evaluation indicators i, q_j refers to the sum of standardized value of evaluation indicators in j year, and it is fixed that when $\frac{q_{ij}}{q_j}$ =0, $\frac{q_{ij}}{q_j}\ln(\frac{q_{ij}}{q_j})$ =0. According to the theory of entropy weight, after the information entropy E_i of evaluation indicator i is figured out, the entropy weight of i indicators can be defined as:

$$Q_i = (1 - E_i)/(n - \sum_{i=1}^{n} E_i) \qquad (i=1,\ 2,\ \ldots\ldots,\ \ n) \tag{10}$$

In Formula (10), Q_i is the entropy weight of evaluation indicator i, E_i refers to the information entropy of evaluation indicator i, n is the number of evaluation indicators. It is also settled that $\sum_{i=1}^{n} Q_i = 1$, $Q_i \in [0,\ 1]$. Based on the theory of information, entropy weight presents an evaluation indicator represents how much useful information an indicator can provide. Thus, in the evaluation indicator system of urban ecosystem sustainable development, the bigger entropy weight of an evaluation indicator is, the more useful information it offers, in other words, it has more effects on the evaluation system.

After calculating the entropy weight of all the evaluation indicators, the urban ecosystem sustainable development capacity G in m year can be derived:

$$G = \sum Q_i X_j \qquad (i=1,\ 2,\ \ldots\ldots,\ n;\ j=1,\ 2,\ \ldots\ldots,\ m) \tag{11}$$

In Formula (11), Q_i is the entropy weight of evaluation indicator i, X_j is the standardized value of the evaluation indicators. The larger G is, the safer the urban ecosystem is and the stronger the urban sustainable development capacity is. Otherwise, the urban sustainable development capacity is weak and may limit the development of the city in the future. In this condition, more attention should be paid to protecting the environment during the process of socioeconomic development.

3.3 Data Sources and processing method

All the data used in the research is from Statistical yearbook of China between 2006 and 2015.

The method of standardizing data in this paper is shown as follows:

$$X' = X_{ij} / \sum X_{ij} \ (i=1,\ 2,\ \ldots\ldots,\ n;\ j=1,\ 2,\ \ldots\ldots,\ m) \tag{12}$$

In Formula (12), X' is the standardized value of evaluation indicators, X_{ij} is the initial data of evaluation indicators.

4. Evaluation results and analysis

By using entropy value method to calculate the weight of each evaluation index (see chart 1), then adopting set pair analysis method, and combined with the original data of “Chinese statistical yearbook (2015)”and “Chinese environmental bulletin (2015)”, it can obtain evaluation results on

Chinese regional economic development, social security, science and education and talent, scientific and technological innovation and entrepreneurship in 2014, The results are shown in table 2.

Table 2 Evaluation results of scientific and technological innovation talent on ecological environment system

	Economic development	Social security	Science and education and talent	Scientific and technological innovation and entrepreneurship
East	0.596	0.667	0.589	0.641
Central	0.492	0.628	0.537	0.591
West	0.473	0.489	0.483	0.497

Table 2 shows that the eastern region has the highest value, and in turn is the central and western regions. This is mainly attributed to faster economic development of eastern region, good overall economic foundation, better basic environment and social security measures, and favourable capital base of most companies, developed science and education level relatively. Because of its geographical location, economic development, history and so on in the central and western regions, it caused that the ecological environment of scientific and technological innovation talent is not perfect. After obtaining evaluation results in 2014, on this basis, apply set pair analysis method again, we can get the whole ecological environment comprehensive evaluation value of scientific and technological innovation talent, as shown in figure 1.

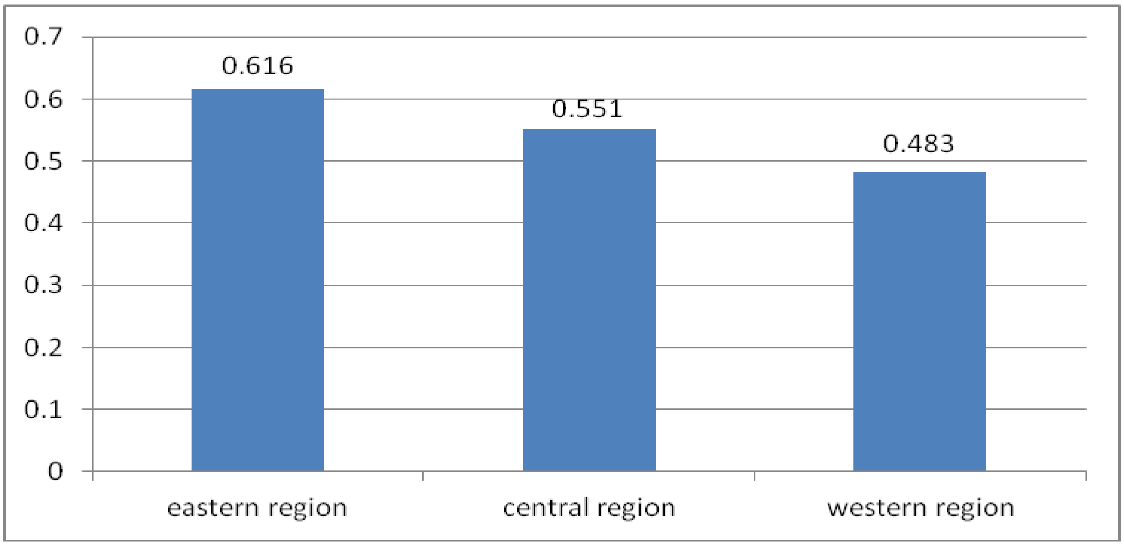

Figure 1 Comprehensive evaluation values of regional scientific and technological innovation talent on ecological environment

From figure 1, it can be found that the comprehensive evaluation value of eastern part is biggest, that is, 0.616; the value in the western region is smallest, 0.483, and the gap between the eastern and western region is larger; the central region ranks second and its comprehensive evaluation value is 0.551. Combined with table 1, with further studies it has founded that social security and scientific and technological innovation and entrepreneurship are the main factors of regional ecological environment of scientific and technological innovation talent. In order to improve ecological environment quality and scientific and technological innovation ability in the central and western regions integrally, therefore, it need continue to provide innovative talents with all kinds of feasible social security measures, and improve the ecological environment and give considerable support on the fund and policy.

5. Conclusions

Based on the comprehensive evaluation index system of ecological environment on scientific and technological innovation talent, the paper uses set pair analysis and entropy value method to analyze Chinese scientific and technological innovation talent ecological environment comprehensively in 2014. The study shows that:(1) Economic development, social security, science and education and talent, scientific and technological innovation entrepreneurship evaluation results show that the eastern region > central region > western region; (2)In the ecological environment comprehensive evaluation of scientific and technological innovation talents, eastern region > central region > western region; (3)with further studies it has founded that social security and scientific and technological innovation and entrepreneurship are the main factors of regional ecological environment of scientific and technological innovation talent.

6. Discussion

The combination of set pair analysis method and the entropy weights can effectively compensate for the deficiencies in evaluation on ecological environment of scientific and technological innovation talents. In this paper, the creative differentiated treatment of original data effectively guaranteed the science and rationality of the research conclusions. However, these approaches have avoided the need for a reference standard of the indicators. This aspect should be improved by further research.

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