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Research on Science and Technology Level of Chemical Industry in China based on the Perspective of Talent Innovation Ability -a Case Study of Yangtze River Delta in China

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At present, there is no industry without chemicals. Without the chemical industry, the economy and society can hardly maintain rapid growth. However, there are some problems in the development of chemical industry such as low chemical technology and slow technological innovation in chemical industry, which can be attributed to the innovation level of innovative talents in chemical industry in China. Therefore, based on the related research, the evaluation index system of technological innovation ability of regional chemical industry is constructed. Taking Shanghai, Jiangsu and Zhejiang provinces in 2016 as an example, the result found that: on the whole, in the comprehensive evaluation of innovation ability of chemical industry talents in science and technology, the evaluation results are as follows: Shanghai>Jiangsu>Zhejiang; the evaluation results of input in science and technology talents in chemical industry are as follows: Shanghai>Jiangsu>Zhejiang; the evaluation results of innovation output of science and technology talents in chemical industry are as follows: Zhejiang> Jiangsu> Shanghai; the evaluation results of innovation and development environment are as follows: Jiangsu> Zhejiang> Shanghai. Finally, we put forward some countermeasures to improve the innovation ability of science and technology talents in China's chemical industry.

1. Introduction

Chemical industry plays an important role in the daily life of mankind in the industrial and agricultural production. It has greatly promoted the development of industrial and agricultural production and enriched people's life. There is no industry in a country without chemical industry, so chemical production is one of the most important industries in our country. However, in the process of development of chemical industry in China, there is a widespread problem of backward production technology, which seriously restricts the improvement of its production efficiency. The improvement of technology in chemical industry mainly depends on the progress of science and technology, and the progress of chemical industry's science and technology depends on the innovation ability of scientific and technological talents. Therefore, taking the Yangtze River Delta in China as an example, it is of great realistic significance to study the innovation level of science and technology talents in chemical industry, which helps to correctly understand its advantages and disadvantages, and reduce the gap with the development of international chemical science and technology.

At present, relevant scholars at home and abroad have less research on the innovative ability of scientific and technological talents in chemical industry. From the point of view of foreign studies, most foreign experts and scholars start from the macro level to conduct systematic research on the theory and practice of innovation of science and technology talents. Some of the main research results are: Guilford (1959) was among the first to summarize the characteristics of innovative talents, and thus set off a wave of innovative scientific and technological talent research. Douglas (2011) et al. studied whether a specific type of people had the potential to become outstanding innovative talents. In addition, some scholars have also studied the role of innovative talents in regional development (Hiltrop, 2005; Hung, 2008)

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There has also been little research on the innovative ability of scientific and technological talents in chemical industry in China. Relevant scholars focus only on the connotation and personality traits of innovative behaviours of science and technology professionals (Wang and Ye, 2014), influencing factors of innovation ability of science and technology professionals (Wang and Zhang, 2015), construction of evaluation index system for innovation ability of science and technology (Gu, 2016; Dong and Zhao, 2016) and innovative talent innovation ability evaluation model (Liu et.al, 2008) and so on.

The chemical industry is the basic industry and the pillar industry of the national economy. From the above analysis, we can see that there is little research on the innovation ability of the scientists and technicians in the chemical industry at home and abroad at present, which is not conducive to the progress of China's chemical industry and the healthy development of the chemical industry.

Therefore, based on the current situation of innovation ability of science and technology in chemical industry of our country, this paper constructs the index system of S & T innovation ability of chemical industry in our country and makes an empirical analysis with Shanghai, Jiangsu and Zhejiang Provinces in the Yangtze River Delta as an example It will provide theoretical support and decision-making basis for accelerating the cultivation of innovative scientists and technicians in the chemical industry, rationally allocating resources for scientific and technological personnel and promoting regional economic development. Thus, according to the current situation of China's chemical industry science and technology innovation ability, constructs the evaluation index system of innovation capability of China's chemical industry science and technology talents, and take China's Yangtze River Delta region of Shanghai, Jiangsu and Zhejiang as an example to do empirical analysis, so as to provide theoretical support and decision-making basis for speeding up the chemical industry science and technology innovation the personnel training, the rational allocation of human resources in science and technology and promote the development of regional economy.

2. Construction of the evaluation index system and the evaluation method

2.1 Establishment of the evaluation index system

Based on the status quo of chemical technology and the development of chemical industry in China, this paper constructs the evaluation index system of technological innovation ability of regional chemical industry is constructed, which is shown in Table 1.

Table 1: Evaluation index system for innovation ability of scientific and technological talents in regional chemical industry

Objective layer	Factor layer	Index layer	Unit	weight
Innovation capabilities of scientific and technological talents	Talent investment (0.370)	Number of R&D personnel	105 persons	0.069
		Proportion of R&D personnel in total employed persons	%	0.072
		Growth of R&D personnel	%	0.043
		R&D investment per capita	109 Yuan	0.065
		Total spending on scientific and technological activities	109 Yuan	0.050
		Proportion of R&D spending in GDP	%	0.071
	Talent output (0.321)	Number of invention patents per R&D personnel	Each	0.082
		Number of scientific research papers per R&D personnel	Each	0.069
		Amount of technical contracts concluded per R&D personnel	109 Yuan	0.084
		Proportion of hi-tech added value in industrial added value	%	0.086
	Talent environment construction(0.309)	GDP per capita	Yuan	0.072
		GDP growth rate	%	0.076
		Average investment in technological transformation per large or medium-sized industrial enterprise	109 Yuan	0.064
		Proportion of the hi-tech industry in GDP	%	0.048
		Cost of scientific and technical personnel per person	Yuan	0.049

2.2 Establishment of the evaluation method

This paper constructs an evaluation method based on intuitionistic fuzzy information to evaluate the competitiveness of China's chemical industry science and technology talents.

(1) The standardization of evaluation indicators

In order to eliminate the difference in non-uniform evaluation index dimensions, we necessarily standardize raw data. If the index value of the target a_i in the evaluation index c_j is x_{ij} the data normalization method of c_j is:

For positive indicators, the normalized formula is:

$$X'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{1}$$

For negative indicators, the normalized formula is:

$$X'_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \tag{2}$$

If the evaluation values of different targets are deemed to obey the normal distribution, we may have $\max x_{ij}=x'_j+3\delta_j$, $\min x_{ij}=x'_j-3\delta_j$ where x'_j and δ_j are the respective mean value and standard deviation of each evaluation index. In the case that the two cycles of values are considered, the standardized value of c_j related a_i may be more than one. We let the smaller one is μ'_{ij}, and the bigger one is μ''_{ij}. In the intuitionistic fuzzy value, the membership degree μ_{ij} is an expression of the worst performance of the evaluation target in the worst criteria. The fuzziness index $\pi_{ij}=1-(\mu_{ij})-(v_{ij})$ reflects the fuzzy degree of μ_{ij}, which means that the actual performance falls into the interval of $[\mu_{ij},1-v_{ij}]=[\mu'_{ij}, \mu''_{ij}]$, where μ'_{ij} and μ''_{ij} are the respective upper boundary and lower boundary of the interval obtained in the process of standardizing evaluation index data (Chen et al., 2014). Therefore, we have $\mu_{ij}=\mu'$, $v_{ij}=1-\mu''_{ij}$.Accordingly; we acquire the intuitionistic fuzzy evaluation data of evaluation indices.

(2) Weight assignment of evaluation indices

The relative importance of a random evaluation indicator c_j in the evaluation index set can be expressed by the weight w_j. As said before, the importance is directly controlled by the competitiveness situations among different schemes. Such being the case, we adopt the entropy weight method to calculate the situation-based index weight.

(3)Collection and comparison of evaluation information

In the evaluation process, we collect the intuitionistic fuzzy evaluation results of different evaluation indices according to the calculation result of intuitionistic fuzzy sets. The formula of a pair of arbitrary intuitionistic fuzzy sets $\tilde{B}$ and $\tilde{Q}$ as well as the real number $\beta \geq 0$ is:

$$\tilde{B}+\tilde{Q}=\left\{\left(\left\langle x,\mu_{\tilde{B}}(x)+\mu_{\tilde{Q}}(x)-\mu_{\tilde{B}}(x)\mu_{\tilde{Q}}(x),\nu_{\tilde{B}}(x)\nu_{\tilde{Q}}(x)\right\rangle\right)\middle| x\in X\right\} \tag{3}$$

$$\tilde{B}\tilde{Q}=\left\{\left(\left\langle x,\mu_{\tilde{B}}(x)\mu_{\tilde{Q}}(x),\nu_{\tilde{B}}(x)\nu_{\tilde{Q}}(x)-\nu_{\tilde{B}}(x)\nu_{\tilde{Q}}(x)\right\rangle\right)\middle| x\in X\right\} \tag{4}$$

$$\beta\tilde{B}=\left\{\left(\left\langle x,1-(1-\mu_{\tilde{B}}(x))^{\beta},(\nu_{\tilde{B}}(x))^{\beta}\right\rangle\right)\middle| x\in X\right\} \tag{5}$$

$$\tilde{B}^{\beta}=\left\{\left(\left\langle x,(\mu_{\tilde{B}}(x))^{\beta},1-(1-\nu_{\tilde{B}}(x))^{\beta}\right\rangle\right)\middle| x\in X\right\} \tag{6}$$

Thus, the target a_i is intuitionistic fuzzy evaluation result obtained in different criteria is $\tilde{a}_i=<v_{ij},v_{ij}>$. According to the index weight vector $w=(w_1,\ldots,w_n)^T$,the comprehensive evaluation result can be expressed by the intuitionistic fuzzy weighed mean operator M_w:

$$\tilde{a}_i=M_w(\tilde{a}_{i1},\ldots\tilde{a}_{in})=\sum_{j=1}^{n}(w_j\tilde{a}_{ij})=\left\langle 1-\prod_{j=1}^{n}(1-\mu_{ij})^{w_j},\prod_{j=1}^{n}(\nu_{ij})^{w_j}\right\rangle \tag{7}$$

Accordingly, the overall and factor-layer-level intuitionistic fuzzy evaluation result of all indices is:

The total value:

$$\tilde{a}_i=\left\langle 1-\prod_{j=1}^{15}(1-\mu_{ij})^{w_j},\prod_{j=1}^{15}(\nu_{ij})^{w_j}\right\rangle \quad (i=1,\ldots,n) \tag{8}$$

The talent investment value:

$$\widetilde{a}_i^{'} = \left\langle 1-\prod_{j=1}^{6}(1-\mu_{ij})^{w_j^{'}}, \prod_{j=1}^{6}(\nu_{ij})^{w_j^{'}} \right\rangle \quad \text{(i=1,…,n)} \qquad (9)$$

The talent output value:

$$\widetilde{a}_i^{''} = \left\langle 1-\prod_{j=1}^{4}(1-\mu_{ij})^{w_j^{''}}, \prod_{j=1}^{4}(\nu_{ij})^{w_j^{''}} \right\rangle \quad \text{(i=1,…,n)} \qquad (10)$$

The talent environment construction value:

$$\widetilde{a}_i^{'''} = \left\langle 1-\prod_{j=1}^{5}(1-\mu_{ij})^{w_j^{'''}}, \prod_{j=1}^{5}(\nu_{ij})^{w_j^{'''}} \right\rangle, \qquad w_j^{'''} = w_j / \sum_{j=1}^{5} w_j, \text{ (i=1,…,n)} \qquad (11)$$

With the comprehensive evaluation result of various schemes, we realize the comparative analysis of talent attraction in different regions. In comparing the volume of two intuitionistic fuzzy sets, we define the score functionΔ and the precise function δof an arbitrary intuitionistic fuzzy set $\widetilde{A} = \langle \mu_{\widetilde{A}}, \nu_{\widetilde{A}} \rangle$ as:

$$\Delta(\widetilde{A}) = \mu_{\widetilde{A}} - \nu_{\widetilde{A}} \in [-1,1], \sigma(\widetilde{A}) = \mu_{\widetilde{A}} + \nu_{\widetilde{A}} = 1 - \pi_{\widetilde{A}} \in [0,1]$$

Thus, for arbitrary intuitionistic fuzzy sets $\widetilde{A} = \langle \mu_{\widetilde{A}}, \nu_{\widetilde{A}} \rangle$ and $\widetilde{B} = \langle \mu_{\widetilde{B}}, \nu_{\widetilde{B}} \rangle$

If $\Delta(\widetilde{A}) > \Delta(\widetilde{B})$, we have $\widetilde{A} > \widetilde{B}$;

If $\Delta(\widetilde{A}) = \Delta(\widetilde{B})$, we have three sub-results:

(a) If $\sigma(\widetilde{A}) > \sigma(\widetilde{B})$, we have $\widetilde{A} > \widetilde{B}$;

(b) If $\sigma(\widetilde{A}) = \sigma(\widetilde{B})$, we have $\widetilde{A} = \widetilde{B}$;

(c) If $\sigma(\widetilde{A}) = \sigma(\widetilde{B})$, we have $\widetilde{A} < \widetilde{B}$.

3. Data sources

The data in this paper are mainly from China Statistical Yearbook (2015-2016), China Statistical Yearbook on Science and Technology (2015-2016) and the Statistical Yearbook for the places (Shanghai, Jiangsu and Zhejiang) in the Yangtze River Delta in China in 2016.

4. Evaluation results and analysis

According to Formula (1) – (11) ,based on the intuitionistic fuzzy information established above and the original value of each evaluation index in 2016, we obtain the evaluation value of technological talents innovation ability of chemical industry in Yangtze River Delta region. Details are shown in Table 2

Table 2: evaluation value of technological talents innovation ability of Chemical industry in Yangtze River Delta region in 2016

	Total value			Investment value		
	μ	v	Δ	μ	v	Δ
Shanghai	0.567	0.404	0.163	0.565	0.369	0.196
Jiangsu	0.531	0.401	0.13	0.572	0.401	0.171
Zhejiang	0.544	0.434	0.11	0.517	0.408	0.109
	Talent output			Environment construction		
	μ	v	Δ	μ	v	Δ
Shanghai	0.519	0.421	0.098	0.531	0.463	0.068
Jiangsu	0.491	0.379	0.102	0.537	0.431	0.106
Zhejiang	0.543	0.414	0.129	0.511	0.434	0.077

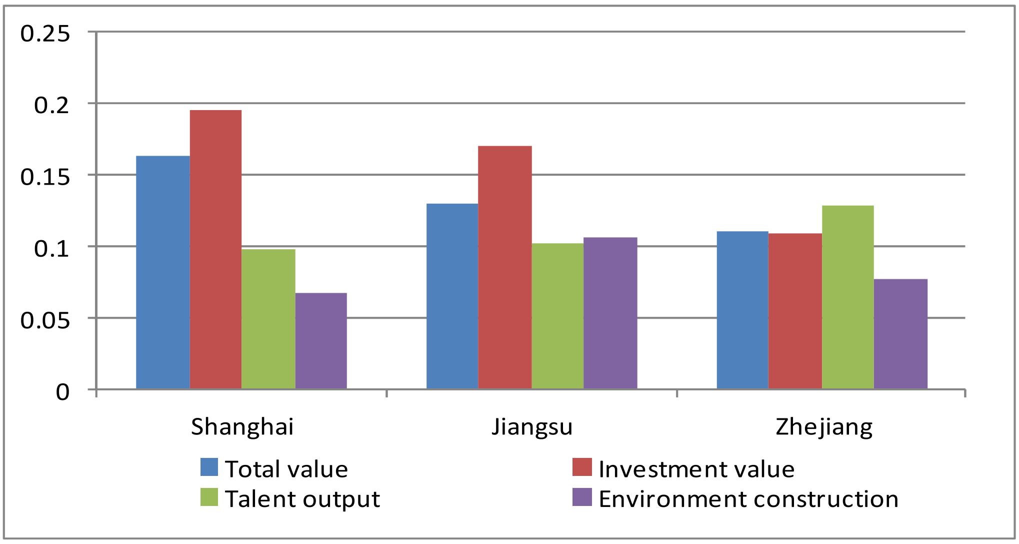

Figure 1: Evaluation results of innovation ability of scientific and technological talents of chemical industry

From Table 2 and Figure 1, we can see that, on the whole, in 2016, in the comprehensive evaluation on the innovation capabilities of scientific and technological talents of chemical industry in the Yangtze River Delta, the innovation capabilities of scientific and technological talents of chemical industry in Shanghai are the strongest, mainly because Shanghai is in a more favourable geographic location where there are a large number of universities and research institutions. The advanced science education resources, centralized talents and sound development environment for scientific and technological talents have enhanced the innovation capabilities of scientific and technological talents in this region and helped preliminarily achieve a good situation where the innovations of scientific and technological talents drive the economic development and transformation. The innovation capabilities of scientific and technological talents of chemical industry in Jiangsu are at the middle level, and those in Zhejiang are the last, which is mainly due to the small number of R&D personnel, slow growth of R&D personnel and small investment in R&D per capita in this province.

Investment on scientific and technological talents of chemical industry in Shanghai is the highest, followed by that in Jiangsu, and that in Zhejiang is the lowest. This is mainly because Shanghai is strategically located, with sufficient financial fund and focus on scientific and technological innovation, which attract a great number of R&D personnel, and at the same time, it has the largest R&D spending and investment in the Yangtze River Delta. The output of scientific and technological talents of chemical industry in Zhejiang is the highest, followed by that in Jiangsu, and that in Shanghai is the lowest. The innovation development environment for the scientific and technological talents of chemical industry in the Yangtze River Delta, the innovative scientific and technological talent construction environment in Jiangsu is the best, followed by that in Zhejiang and then that in Shanghai. In recent years, the economic development environment in Jiangsu Province has been stable and the chemical industry has developed rapidly. All these have provided a good environment for the innovation of science and technology talents in the chemical industry in Jiangsu.

5. Conclusions

The chemical industry occupies a very important role in the development of the national economy. The innovation level of chemical technicians directly determines the level of economic and social development in a country or a region. Based on the relevant researches, this paper takes the innovation and development status of chemical industry talents in the Yangtze River Delta of China as an example for empirical analysis. The results show that: on the whole, in the comprehensive evaluation of innovation ability of chemical industry talents in science and technology, the evaluation results are as follows: Shanghai> Jiangsu > Zhejiang; the evaluation results of input in science and technology talents in chemical industry are as follows: Shanghai> Jiangsu> Zhejiang; the evaluation results of innovation output of science and technology talents in chemical industry are as follows: Zhejiang> Jiangsu> Shanghai; the evaluation results of innovation and development environment are as follows: Jiangsu> Zhejiang> Shanghai.

The ability of innovation of science and technology talents is directly related to the level of development of chemical industry in our country. In order to give full play to the important role of science and technology talents in chemical industry, our country should continue to optimize the growth environment of innovative science and technology talents in chemical industry and create a humanistic Environment, explore the establishment of high-level innovative scientific and technological personnel gathering mechanism.

Talent in science and technology innovation ability is directly related to the level of development of China's chemical industry, to better play a major role in science and technology talents of chemical industry, China should continue to optimize the environment for the growth of the chemical industry technology innovation talents, innovation and entrepreneurship to create high-level talents of the human environment, establish scientific and technological talents agglomeration mechanism.

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