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Regional Competitiveness Evaluation in Chemical Industry

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This paper aims to analyse the regional competitiveness evaluation in the chemical industry. To this end, by taking the four regional chemical industries in Beijing, Tianjin, Jiangsu, and Anhui as object of study, the related evaluation method, principle, and model etc. were adopted. The research results show that the chemical industry in Beijing ranks first, exhibiting the relatively stronger overall regional competitiveness. Therefore, it is concluded that the regional centralization in regional chemical industry should be intensified to improve its industrial competitiveness.

1. Introduction

As one important part of social economic development, the chemical industry is of significant importance. Besides, from the perspective of heavy-chemical engineering industry, the electronics, energy and mechanical manufacturing etc. all belong to chemical engineering industry, with widely distribution in market economy and greater influence. Now, at the important social transformation stage, all walks of life are faced with opportunities and challenges, so the competitiveness research is conducted in more fields to explore how to strengthen its own development. But there have been few researches on the regional competiveness in chemical engineering industry. Hence, by mainly taking the evaluation study of regional competiveness in chemical industry as object of study, the related evaluation system, methodology and model etc. were applied in the case study. Figure 1 shows a regional chemical industry production base.

Figure 1: A regional chemical industry production base

2. Literature review

Since the reform and opening up, China's chemical industry has developed rapidly. By 2015, the total production volume of China's petrochemical industry has leapt to second place in the world, second only to the United States. Excluding petroleum refining, China’s total chemical industry has surpassed the United States and ranks first in the world. In 2014, China’s main chemical industry revenue reached 8.76 trillion yuan, and the US’s main chemical revenue was $805 billion, equivalent to RMB 4.94 trillion (2014 exchange rate). China's chemical industry's main revenue was 77.3 higher than the United States in 2014, ranking first in the world. Japan’s chemical industry’s main revenue is 2.3 trillion yuan, which ranks third in the world, and

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Germany ranks fourth with 1.6 trillion yuan. From the above data, we can conclude that China has far exceeded Japan and Germany. On the other hand, in recent years, the profit rate of China's chemical industry has continued to decline. There are many reasons such as the repeated construction of the industry, the constraints of environmental pollution on the production, the unreasonable distribution of chemical companies, the shortcomings and shortages of high-value-added products and high-tech products, and the seriousness of security incidents. If these fundamental problems cannot be solved effectively, it will seriously restrict and affect the sustainable development of the chemical industry. The chemical industry is a pillar industry of a country’s national economy. Its development directly or indirectly affects the economy, society, and people’s lives in China.

At present, major changes have taken place in the internal and external environments of China's petroleum and chemical industries. From an international point of view, the impact of the international financial crisis environment has a long-term effect, and the impetus for the recovery of the world economy is insufficient. It is difficult for the international market demand to return to the high growth stage before the financial crisis. The saturation of investment capital will also be greatly affected. Therefore, in the field of chemical industry, the depth adjustment of the global industrial structure will become the main theme. The competition will become more fierce. Whoever has a more efficient and deeper structure will take the lead in cruel competition. Wang pointed out that advanced economies rely on the advantage of scientific and technological innovation to accelerate the adjustment of industrial structure, promote the diversification of raw materials and high-end products, and extend into high-performance, high-value-added products (Wang and Wang, 2014). All of these have formed a great competitive pressure on China's chemical industry. Kim et al. (2016) pointed out that since 2015, international crude oil prices have dropped significantly. Not only petroleum, but also upstream companies such as oil refining have been greatly affected, even directly affecting all nodes in the entire chemical industry chain in China. Liu (2016) pointed out that China's national economy has entered the new normal for development, and it faces both new opportunities and new challenges. It is advantageous that under the new normal, China's economic fundamentals have not changed for a long time. Economic growth still ranks among the top in the world. Domestic demand has great market potential, creating a long-term and stable market demand for the petrochemical industry. Disadvantageously, due to the transition period of economic growth shift, industrial restructuring will surely adversely affect the development of enterprises. Especially in the situation of limited resources, increased environmental constraints, overcapacity of some products, and rapid increase in cost (including labor costs), product prices have declined due to international and domestic competition and formed a market retreat mechanism. The development of the chemical industry faces a series of prominent conflicts.

Siirola (2014) took an ecological heavy chemical industrial base as an example to discuss and analyze potential environmental problems in the development of heavy chemical industrial bases. Examples of environmental pollution in heavy chemical industrial parks have been developed with advanced Kuznets time series curves and second-degree grey correlation methods, and the indicators of “*Integrated Eco-Industrial Parks*” have been used as references. On this research, a novel analysis method is used to study the pollution problems in heavy chemical industry parks, which is worth learning. For the sustainable development of chemical industry parks, pollution is a top priority. Lin and Long (2015) used Qilu Petrochemical as a research center to discuss the research issues on the construction of circular economy in Shandong Zibo Chemical Industry Zone. The analysis of the status of environmental pollution in the surface water and groundwater of the Qilu Petrochemical Chemical Industrial Park was conducted with the single factor environmental pollution index evaluation method. Water is not only an essential medium for almost all processes in the chemical industry, but it is also one of the ultimate carriers of pollutants excreted in chemical processes. The pollution analysis and solution of water resources in the eco-chemical industrial park are worth learning. Broeren et al. (2014) discussed the chemical company's environmental medicine with BASF as an example. It discusses not only the environment but also the employees of chemical companies. Inspired by this, employees of chemical companies are also an integral part of sustainable development. Wang et al. took Dongying Chemical Park as an example to discuss its external environment and internal conditions. Based on this, they conducted strategic planning and analysis (Wang et al., 2014). Among the studies on regional chemical industry, some well-known foreign experts have mentioned their planning and strategic research. Some of the famous works include Grader in America, “Industrial Ecology” by Allenby, Japan's Masahisa Fujita, and the “Agglomeration Economics” by Thys, Belgium (Luis et al., 2014; Tirmizi et al., 2017).

In summary, the internal and external environments, circular economy, environmental issues, and pollution in the petrochemical industry were mainly studied deeply. However, competitive research in the chemical industry system is rarely with professional evaluation methods and models. Therefore, based on the above research status, the research on the regional competitiveness evaluation of the chemical industry is mainly used as the research object, and the relevant evaluation systems, evaluation methods and models are used to study the cases.

3. Methodology

3.1 Establishment principle of evaluation system index

The measurability of scientific index can directly influence the accuracy in reflecting the inputs and outputs etc. of chemical industry cluster, and further in its competitiveness, so the selected index should be of scientificity. Besides, in view of numerous influencing factors on chemical industry cluster competiveness, the comprehensiveness and representativeness should be taken into the index selection so as to ensure the accurate evaluation of chemical industry cluster competiveness. Furthermore, in terms of comparability, only by comparing with other industry clusters in other Chinese regions, the competitiveness in chemical industry cluster can be evaluated exactly; as a result, when selecting the index, based on the other three principles such as scientificity, comprehensiveness, and representativeness, the selection of common features in different regions can guarantee the evaluation and comparison of chemical industry cluster competitiveness among all regions. Finally, the authenticity and feasibility of index data is the research basis for chemical industry cluster competitiveness evaluation, because the practical value of research can be realized only by the data authenticity. Therefore, in this paper, related data are collected in some official statistical materials in chemical industry to ensure data authenticity; also, the feasibility can be made, because of easily data acquisition and simpler computing method.

3.2 Selection of evaluation method

Based on the continuous in-depth researches of the scholars at home and abroad on the chemical industry cluster competitiveness, more evaluation methods have been developed accordingly, including the following commonly applied ones: location coefficient method (LQ coefficient method), logistic model, the analytic hierarchy process (AHP), and principal component analysis (PCA). LQ coefficient method is to identify the industry cluster phenomenon on the basis of industry cluster definition. In the logistic model, the stability of chemical industry cluster is analysed mainly by describing the structure, development mode, and output level of chemical industry; currently this model is mostly adopted to study the stability between the complete-vehicle enterprise and small & medium-sizes matching enterprises. Analytic hierarchy process (AHP) is combined with fuzzy evaluation to evaluate the chemical industry cluster competitiveness. But there exist certain defects with these methods: 1) Subjectivity. The subjective weight evaluation might over-estimate or underestimate the influence of one certain index on the chemical industry cluster competitiveness, reducing the effectiveness of evaluation results; 2) Correlation. In the evaluation process, the repeated index evaluation and usage could make it difficult to truly reflect the evaluated object. The principal component analysis (PCA) is to transfer majority of index into the typical principal index so as to avoid the collinearity problems of variables with the strong objectivity. In this paper, the principal component analysis is conducted to collect the related data to reveal the advantages and disadvantages of cluster competitiveness in Guangxi Chemical industry.

3.3 Evaluation methodology and model

The data envelopment analysis (DEA) can be applied to obtain the relative efficiency evaluation results between multi-inputs and multi-outputs. It is applicable to economic management by generating the related profound meaning and useful information.

For the decision-making unit, the optimal input/output plan should be fully considered to better reflect its own information characteristic of evaluated object and the general effect of industrial system inputs on system outputs for providing the better decision-making information for the managers. By the weight variables of decision-making unit input and outputs, the evaluation can be made from the perspective most favourable to the decision-making unit, so as to avoid the determination of preferential meaning weights for each index; besides, the relationship between inputs and outputs doesn't need to be determined, with a stronger objectivity by excluding the interference of subjective factors.

Banker-Charnes-Cooper model (BCC) is the improved version based on C2R model. C2R model is the constant returns to scale (CRTS) model by judging whether the system activity can achieve the technological efficiency (TE). TE includes pure technological efficiency (PTE) and scale return efficiency (SRE). The super-efficiency model can ensure the comparison and evaluation among multi-decision-making units; the efficiency evaluation results in this model coincide with that of BCC model.

3.4 Samples

To analyse the competitiveness of chemical industry cluster, this paper divides the level-one index into different items such as cluster scale competitiveness, cluster growth competitiveness, cluster investment competitiveness, cluster management competitiveness, cluster management competitiveness, cluster cultural environment competitiveness, and cluster trust and collaboration reflecting its overall competitiveness level in different aspects. Table 1 shows evaluation index system of chemical industry cluster competitiveness.

Table 1: Evaluation index system of chemical industry cluster competitiveness

The total target layer	Level indicators	The secondary indicators
Competitiveness of chemical industry cluster	Cluster scale competitiveness	Net fixed assets, floor area
	Cluster growth competitiveness	Operating income, total output value, fixed asset value increase rat
	Cluster investment competitiveness	Total assets profit margin, fixed assets investment profit margin
	Cluster management competitiveness	Current assets turnover rate, sales profit margin
	Cluster market competitiveness	Industrial output value, industrial added value
	Cluster cultural environment competitiveness	Industry cluster visibility, policy system integrity
	Cluster trust and cooperation	Team spirit, cluster network maturity

The principal component analysis in SPSS 19.0 statistical analysis methods is applied to analyse the chemical industry cluster competitiveness in Guangxi Province. Due to different original data statistical standards, firstly these original data indexes were standardized, and then the analysis of principal components was made for these standardized data to obtain the correlation coefficient matrix. Table 2 shows raw data of chemical industry in 4 regions in China

Table 2: Raw data of chemical industry in 4 regions in China

name	Sales value	Net fixed assets	The production USES the floor area	The added value of Increase the rate of	The value-added rate of operating income	Total output increase rate
Beijing	21239180	4403049	88065	6.40	7.90	7.90
tianjin	15643935	2616861	60934	6.4	7.90	-6.05
jiangsu	16415297	3229360	114961	7.89	7.90	-6.60
anhui	16719438	3393387	122755	9.11	7.90	7.90

4. Results and analysis

4.1 Input factor analysis of chemical industry competitiveness

There are 29 sub-indexes of input factors altogether analysing the chemical industry competitiveness. The factor analysis was made for these 29 input indexes. The results are shown as table 3 and table 4.

Firstly, the commonness of variables is measured; with the higher commonness between the variables, they'll be suitable for factor analysis. Most variables have the higher approximation (about 80%-90) for the extracted common factor. Then, the factor interpreting ability is extracted; the first three characteristic root values extracted per cumulative variance contributions are over 1.00 common factors, which can interpret more than 72.91% interpreting information of research variables.

In the rotated load matrix, it is found that the first common factor FI1 has the relatively larger load proportion in the 16 input indexes such as Etot, GDPG, RDII, TI, GAG, GA, CII, EEI, RDIG, RDEG, CIG, RLIG, ECG, EG, EEG, and TIG; the second common factor FI2 in the 7 input indexes: EEtot, EII, ECtot, RLI, CItot, ERDtot, and

RDItot; the third common factor FI3 in the 6 input indexes: GDP, RDEtot, ERDI, RDEI, ERDG, and ECI. According to factor analysis results, the scores of FI1, FI2, and FI3 could be achieved for further use.

Table 3: Analysis result of factor analysis for the competitiveness of chemical industry

Serial number	Name of factors	sub-index
FI1	Input factor 11	Etot, GDPG, RDII, TI, GAG, GA, CII, EEI, RDIG, RDEG, CIG, RLIG, ECG, EG, EEG, TIG
FI2	Input factor12	EEtot, EII, ECtot, RLI, CItot, ERDtot, RDItot
FI3	Input factor13	GDP, RDEtot, ERDI, RDEI, ERDG, ECI

4.2 Output factor analysis of chemical industry competitiveness

There are 25 sub-indexes of output factors altogether analysing the chemical industry competitiveness. The factor analysis was made for these 29 input indexes. Most variables have the higher approximation for the extracted common factors. Then, the factor interpreting ability is extracted; the first three characteristic root values extracted per cumulative variance contributions are over 1.00 common factors, which can interpret more than 80.55% interpreting information of research variables. It is found that the first common factor FO1 has the relatively larger load proportion in the 12 output indexes such as EXtot, EXCtot, NEXtot, EStot, EPtot, EUVI, EXCN, EOItot, EPC, ESC, EOII and Rtot; the second common factor FO2 in the 5 output indexes: PC, NPtot, Stot, SC, and OPtot; the third common factor FO3 in the 8 output indexes: PAI, PG, SG, RAI, EPG, EXG, ESG, and EOIG. According to factor analysis results, the scores of FO1, FO2, and FO3 could be achieved for further use.

Table 4: Analysis results of factor analysis of the competitiveness of chemical industry

Serial number	Name of factors	sub-index
FO1	Output factor O1	EXtot, EXCtot, NEXtot, EStot, EPtot, EUVI, EXCN, EOItot, EPC, ESC, EOII, Rtot
FO2	Input factor O2	PC, NPtot, Stot, SC, OPtot
FO3	Input factor O3	PAI, PG, SG, RAI, EPG, EXG, ESG, EOIG

4.3 Comprehensive factor analysis of standardized data

Table 5: Scores of comprehensive factors

name	score	ranking
Beijing	8.25	1
tianjin	7.18	2
jiangsu	2.63	3
anhui	2.03	4

The comprehensive evaluation score table of chemical industry cluster competitiveness shows that Beijing ranks first in the overall chemical industry competitiveness; the chemical industry cluster formation in Tianjin plays a decisive role in promoting its dominant position and preserving its competitiveness, so Tianjin ranks second, because it has lower production scale, economic benefit, and growth potential by comparing with Beijing in Chemical industry competitiveness. Table 5 shows scores of comprehensive factors.

5. Conclusion

With the rapid economic development, the global competitiveness in chemical industry becomes more intensified. In this background, the chemical industry cluster has turned to be one new mode in chemical industrial competition. The enterprises inside the cluster could share resources and reduce risks to cut down the cost and improve benefits, besides, for the longer-chain industry, the industrial cluster can be applied to promote its competitiveness in its region, in China or even abroad. So, to cultivate and develop the industrial cluster in chemical areas can effectively and rapidly booster the chemical industry, and further drive the local economic development. Finally, by comparing with the related data, it can be seen that the domestic chemical industrial cluster has formed one well-organized industrial chains structure with higher development potential and maturity.

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