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A Study on the Competitiveness of Chinese Nonferrous Metals Industry Based on Principle Component Analysis

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Abstract: Based on the theories of regional economics and industrial economics, the paper analyzed the development of China nonferrous metals industry, made summary of the current research on industrial competitiveness, built an evaluation index system from the four areas: scale competitiveness, market competitiveness, benefit competitiveness and export competitiveness. Then, with the tool of SPSS, the paper conducted principal component analysis to evaluate the competitiveness of China's nonferrous metals industry. The principal component analysis showed that 2 principle components, named as market competitiveness and benefit competitiveness, can be extracted to evaluate china's nonferrous industrial competitiveness. It is concluded that the competitiveness of Chinese nonferrous metals industry has been improving, and it also came up some suggestions on how to further improve the competitiveness of Chinese nonferrous metals industry from the two areas: adjust the industrial structure and improve the technological level.

Keywords: nonferrous metals industry, competitiveness, principle component analysis

1. INTRODUCTION

Nonferrous metals are applied in many industries such as aviation, aerospace, automotive, machinery, electricity, telecommunication, construction and household appliances, etc. With the modernization of agriculture, industry and the rapid development of science and technology, as it provides the basic materials for national economical development, the nonferrous metals industry is becoming more and more important in the course of human development. China will still be in the process of industrialization in the first 20 years of the 21st century. The rapid development of manufacturing sector will drive up the national economy maintaining a quite long period of rapid growth. Therefore, as an industrial base, the nonferrous metals industry plays even more important role in assuring China to keep its economy in a rather high growth rate. As a result, it's of great significance to take a study on China nonferrous metals industry from the perspective of industrial competitiveness.

The object of this paper is to decipher the industrial competitiveness of Chinese nonferrous metal industry by the method of principal component analysis. The reminder of the paper is organized as follows: section 2 makes summary of the current research on industrial competitiveness, section 3 discusses the current development of Chinese nonferrous metal industry, section 4 develops an evaluation index system and evaluates the competitiveness of Chinese nonferrous metal industry based on principal component analysis, Section 5 makes development strategies, and section 6 discusses the future research direction

2. CURRENT DEVELOPMENT OF CHINA NONFERROUS METALS INDUSTRY

According to the different research perspective and focus, the term competitiveness has multi-level and multi-dimensional meanings. There is no unified definition for it in economics. In general, industry competitiveness compares certain industry in certain country or region to others in respects such as production efficiency, the ability to meet market demands and gain continuously profit, etc, embodied in the differences

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comparing to other competitors in respects such as, scale, market, efficiency and exports. In 1817, David Ricardo described his theory of comparative advantage; he thinks industry competitiveness can be gained by participating international competition after comparing the advantages towards other countries. In 1890, Marshall described his theory of scale economy, studied the variation of the reward of scale economy; he thinks industry competitiveness can be gained through expanding production scale. In 1980's, Michael Porter[1] presented his theory of competitive advantage, and built his 5 force model of industry competition and diamond model of national competitiveness.

The Chinese studies on industry competitiveness started quite late. In 2003, through building the theoretical model of industry competitiveness, conducting quantitative analysis by using competitive indicators which has the features of number representations to interpret the formation mechanism of industry competitiveness, Jin Bei[2] expanded the industry competitiveness research area to industrial organizations, industrial clusters etc.; he even studied industry competitiveness from perspectives such as international economics, development economics, regional economics and institutional economics. In 2002, Wei Houkai [3]and others used 5 indicators including powers of market influence, industrial growth, resource allocation, structural transformation and industrial innovation to evaluate regional industrial competitiveness. In 2003, Cai Fang[4] proposed industry competitiveness as a dynamic concept, which is certain industry's ability of response and adjustment towards its national resources endowment (shown as comparative advantages); mainly shown as the overall allocation of resources and their effects of certain industry in certain country or region. It is conclude that the industry competitiveness directly relates to how it follows the principle of comparative advantages. In 2006[5], Rui Mingjie embedded the ability of absorbing knowledge and being innovative in the diamond model, and thinks that's the core for developing industrial sustainable competitiveness. However, current studies lack the research on nonferrous metal industry, and this paper aims to make empirical study on evaluation of nonferrous metal industry competitiveness.

3. CURRENT DEVELOPMENT OF CHINA NONFERROUS METALS INDUSTRY

3.1 Scale of the china nonferrous metals industry

The nonferrous metals production earned steady growth during the eleventh five year plan time (2006-2010); plus, the investment in fixed assets in this industry has kept increasing; the total import and export volume of nonferrous metals showed great increase. In 2009, it reached 83.197 billion USD$ and its average annual growth rate is 15.45%; the average annual growth rate of the import reached at 21.41%, and the rate for export is 1.15%[6]. Meanwhile, the energy consumption of the major products decreased and the technical and economic indicators improved significantly.

While the scale increasing, the level of nonferrous metals technology and equipment have been significantly improved. This mainly shows at the following two aspects: firstly, We've done independent research and development on mineral separation – Bayer alumina production process and sandy alumina production technology; the technology and equipment of the back bone copper smelting enterprises have reached the world advanced level; the trial production of the liquid high-lead slag direct reduction made a success and the Kivcet direct lead smelting process is being introduced. Secondly, the technology and equipment of copper processing have improved fast, making important progress in areas such as energy saving, material saving, process shortening, production volume increasing, quality improving and production cost lowering etc. Meanwhile, we managed to have independently developed the world class 10 thousand ton-grade oil hydraulic dual-drive extruder. Also, there are major progresses made in the R&D of nonferrous alloys and composite materials through innovation, integrated innovation and re-innovation after digesting, absorbing the introduced technology.

3.2 Resource and Production Quality

As for the resource development, the nonferrous geological exploration has made remarkable achievements, and the maintain reserves has been significantly improved. Up till the end of 2008, the national reserves of cooper resource reached 77.09 million tons, lead 45.49 million tons, zinc 103.93 million tons, bauxite 3.03 billion tons. There's also certain progress made on overseas resource development. CHALCO obtained mineral development license at the Aurukun project in Australia; CNMC's first project at the Chambish Copper Mine in Zambia has been put into operation with 47 thousand tons of copper mine yearly capacity; MCC gained 30 thousand tons of copper mine yearly capacity through lease production at Saindak Copper Production in Pakistan[7].

Currently, the quality of the Chinese nonferrous metals smelting products has reached the world advanced level. Specifically, there have been 64 brands in the 10 products including copper, aluminum, lead, zinc, tin, nickel, silver, cobalt, special aluminum and aluminum alloy which have registered at London Technical Exchange and London Bullion Market, maintaining a rather high level pass rate. Meanwhile, the quality of the processed products is improving fast. The quality of aluminum foil, PS printed board base and high-voltage anode foil for voltage devices has reached the level close to international advanced standards. The precision brass products are going towards the direction of "higher, finer and stronger", and already being exported in big volumes to developed countries like the U.S. and etc. Copper alloy seamless pipe used on desalination equipments are exported in big volumes to the developed countries and regions such as Japan, the U.S. and Europe. These fully show the strength of China's nonferrous metals processing industry.

3.3 Nonferrous Metals Industry Structure

In the past years, the state managed to eliminate the bad production capacity and make the industrial layout and regional distribution more reasonable through macro-control. For example, the electrolytic aluminum industry has eliminated the self-baking cells, all the new and expanded projects adopted large scale pre-baking cells above 300KA; currently, the ability of nonferrous metals resource development and smelting capacity are transferring from east China to the middle and west China; the copper, lead, zinc industry structure is being adjusted to the direction of integrating mining, smelting and processing; the variety of nonferrous metals processing is getting increasingly sophisticated, and the product structure more reasonable.

Pushed and encouraged by the state nonferrous metals industry revitalization plan, a number of highly competitive large enterprise groups were formed through mergers and acquisitions. This brought fast development of the industry and progress in technology. The sustainability and competitiveness of the industry got upgraded; the industrial concentration has also been significantly improved. For example, CHALCO actively integrated domestic resources, speeded up opening up a wide range of global business and product portfolio, its electrolytic aluminum production has reached 3.31 million tons, now it has become the 2nd largest alumina and the 3rd largest electrolytic aluminum manufacturer. Currently, the top 10 smelting enterprises together take 75% of the national production yield; there are 6 enterprises whose electrolytic aluminum production surpassed 500 thousand tons, their total production has reached 6.6 million tons, taking 51.3% of the national electrolytic aluminum production yield[8].

3.4 Development of Nonferrous Metals Industry Standards

The development of nonferrous metals industry standards also has jumped to a new level. Up till the end of 2009, the total number of nonferrous metals industry standards reached 2,103, including 953 national standards, 1,020 industry standards and 130 national military standards[9]. Meanwhile, the nonferrous metals industry has increased the pace on international standardization. The good Chinese standards are going on to the international stage in various forms. Many of the international standards and the advanced foreign standards have been adopted as Chinese standards. China is taking part in the international standardization activities to keep abreast

of the new trends. Up till now, both the ISO/TC26 (copper and copper alloys) and TC79/SC5 (magnesium and magnesium alloys) have set up their secretariats in China.

4. EVALUATION OF COMPETITIVENESS OF CHINA NONFERROUS METALS INDUSTRY

4.1 Establishment of competitiveness evaluation indicator system

This research established China nonferrous metals industry competitiveness evaluation system, based on the content of comprehensive industrial competitiveness[10]-[12], following the principles of objectivity, feasibility, relativity and comparability. It reflects the competitiveness of nonferrous metal industry in 4 areas as below: 1) scale competitiveness (A1), including the ratio of nonferrous metal industrial Added Value to national GDP (A11), Proportion of the nonferrous metal industrial Output Value to national total industry output value (A12) and Average Annual Number of Employees (A13); 2) market competitiveness (A2), including the proportion of the nonferrous metal industrial Sales Revenue to national total industry sales revenue (A21), Proportion of the nonferrous metal industrial profit to national total industry Profit (A22); 3) benefit competitiveness (A3), including contribution rate of total assets (A31), asset-liability ratio (A32) ’current assets turnover rate（A33）’ ratio of cost and expense to sales (A34), and ratio of sales revenue to total industrial output (A35); 4）export competitiveness, including proportion of the nonferrous metal industrial export value to national total export (A41) and the proportion of the nonferrous metal industrial import value to national total import (A42).

4.2 Evaluation based on principle component analysis

Principle component analyses (PCA) is a multivariate statistical analysis, whose main idea is to transfer a number of indicators into a few composite indicators through dimensionality reduction [7]. The analysis is done on a few comprehensive indicators selected, studying the link and quantitative relationship between each comprehensive factor and the original index set to determine the internal structure of each comprehensive factor and identify the economic implications of each comprehensive factor, building a comprehensive evaluation model on industrial competitiveness based on each comprehensive factor’s variance contribution rate.

4.2.1 Data collection

The data of this study comes from the database of www.ce.cn , import-export data comes from “China Customs Statistics Yearbook” (2002-2009). Using SPSS18.0 software, Calculation of those data is conducted with the method of principle component analysis.

4.2.2 Evaluation result

Results are shown as in the table 1 and table 2. As in table 2-1, 2 principle components with cumulative squared difference of 90.897% is extracted, which are assumed to be alternative to other variables.

Table 1. Principle component extraction-the total variance explained

Component	Initial Eigen-Value			Extracting Square and Load		
	Total	% of Variance	% of Cumulative	Total	% of Variance	% of Cumulative
1	9.689	80.742	80.742	9.689	80.742	80.742
2	1.215	10.125	90.867	1.215	10.125	90.867
3	.916	7.636	98.503			
4	.086	.720	99.223			
5	.057	.473	99.696			
6	.028	.231	99.927			
7	.008	.064	99.991			
8	.001	.009	100.000			
9	3.876E-16	3.230E-15	100.000			
10	4.628E-18	3.856E-17	100.000			
11	-9.901E-17	-8.251E-16	100.000			
12	-4.015E-16	-3.346E-15	100.000			
Extraction Method: Principle Component Analysis						

Table 2. Principle component matrix

	Component	
	1	2
ratio of nonferrous metal industrial Added Value to national GDP(A11)	.872	-.352
Proportion of the nonferrous metal industrial Output Value to national total industry output value(A12)	.944	.112
Average Annual Number of Employees(A13)	.926	-.359
the proportion of the nonferrous metal industrial Sales Revenue to national total industry sales revenue(A21)	-.474	.535
Proportion of the nonferrous metal industrial profit to national total industry Profit (A22)	.797	.565
contribution rate of total assets (A31)	.886	.434
Asset-Liability Ratio(A32)	-.978	.118
current Assets Turnover Rate(A33)	.974	.127
ratio of cost and expense to sales (A34)	-.968	.142
ratio of sales revenue to total industrial output (A35)	-.935	.205
proportion of the nonferrous metal industrial export value to national total export (A41)	.995	.045
proportion of the nonferrous metal industrial import value to national total import (A42).	-.913	-.250
Extraction Method: Principle Component Analysis		
a. 2 components extracted.		

According to the component matrix in the table, as for the 1st component, there is relatively large correlation in ratio of nonferrous metal industrial Added Value to national GDP, Proportion of the nonferrous metal industrial Output Value to national total industry output value, Annual Average Number of Employees, Asset-Liability Ratio, current Assets Turnover Rate, proportion of the nonferrous metal industrial export value to national total export; as for the 2nd component, there is relatively large positive correlation in the proportion of the nonferrous metal industrial Sales Revenue to national total industry sales revenue, Proportion of the nonferrous metal industrial profit to national total industry Profit, and Contribution Rate of Total Assets. Therefore, the 2 principle components

Table3. Component score coefficient matrix

	Component	
	1	2
ratio of nonferrous metal industrial Added Value to national GDP(A11)	.090	-.290
Proportion of the nonferrous metal industrial Output Value to national total industry output value(A12)	.097	.092
Average Annual Number of Employees(A13)	.096	-.296
the proportion of the nonferrous metal industrial Sales Revenue to national total industry sales revenue(A21)	-.049	.440
Proportion of the nonferrous metal industrial profit to national total industry Profit (A22)	.082	.465
contribution rate of total assets (A31)	.091	.357
Asset-Liability Ratio(A32)	-.101	.097
current Assets Turnover Rate(A33)	.100	.105
ratio of cost and expense to sales (A34)	-.100	.117
ratio of sales revenue to total industrial output (A35)	-.096	.168
proportion of the nonferrous metal industrial export value to national total export (A41)	.103	.037
proportion of the nonferrous metal industrial import value to national total import (A42).	-.094	-.206

Extraction Method: Principle Component.
Composition Score.

extracted can be respectively named as market competitiveness and benefit competitiveness.

According to the score matrix in the table 3, we get the values of the 2 principle components, namely, the evaluation values of market competitiveness (F_1) and benefit competitiveness (F_2). The formulas are as below:

$$F_1=0.090*A_{11}+0.097*A_{12}+0.096*A_{13}-0.049*A_{21}+0.082*A_{22}+0.091*A_{31}-0.101*A_{32}+0.1*A_{33}-0.1*A_{34}-0.096*A_{35}+0.103*A_{41}-0.094*A_{42} \quad (1)$$

$$F_2=-0.290*A_{11}+0.092*A_{12}-0.296*A_{13}-0.440*A_{21}+0.465*A_{22}+0.357*A_{31}+0.097*A_{32}+0.105*A_{33}+0.117*A_{34}+0.168*A_{35}+0.037*A_{41}-0.206*A_{42} \quad (2)$$

Then we get the comprehensive competitiveness of the nonferrous metals industry based on the variance contribution rates $F=0.80742*F_1+0.10125*F_2$. See the F Values of the nonferrous metals industry comprehensive competitiveness from 2001 to 2009 at table 2-4.

Table 4. Nonferrous Metals Industry Comprehensive Competitiveness from 2001 to 2009

Year	Market Competitiveness	Benefit Competitiveness	Comprehensive Competitiveness
2001	-3.459033503	-5.292345927	-3.328742856
2002	1.215039613	-19.52055533	-0.995408943
2003	4.182801659	-26.74385925	0.669461966
2004	5.984600197	-26.9598548	2.102400592
2005	8.414836684	-31.63233273	3.591533747
2006	10.08421644	-33.23533278	4.777120591
2007	13.23915567	-42.16705158	6.420145095
2008	15.54705692	-52.75183668	7.211881236
2009	13.85791843	-50.64566742	6.061286673

The results in the table 4 shows, the comprehensive competitiveness of China nonferrous metals industry has always been improving. A certain decrease showed in 2009, which was unavoidable, is due to the global financial crisis.

5. SUGGESTIONS

The world nonferrous metals industry has made significant changes since 1990's. In the past years, the production yield of nonferrous metals has been continuously increasing. The manufacture of primary products is moving towards low-cost regions; the foreign large scale nonferrous enterprises and the multi-national companies are accelerating the development of new high-tech material products to increase their competitiveness; multi-national corporation groups are being formed through capital management such as mergers and acquisitions. Facing such fierce international competition, China nonferrous metals industry should speed up the reform and development, formulate effective development strategies to meet all kinds of challenges.

5.1 Adjust the organizational structure

For the nonferrous metals enterprises, the best mode of production is to pursue scale benefit, which somehow also affected by the operational characteristics. All kinds of enterprise groups can be formed through mergers and acquisition, co-running and equity participation, to promote restructuring of the stock assets, so as to achieve maximum benefits, meet the market demand, and take an invincible position in the fierce competition. The government should support the small and medium-sized enterprises for professional development, to improve their specialized production strength, and change the excessive competition situation.

5.2 Improve the technological level

Technology is the core of an industry, playing a very important role in the development of it. Improving the technological level can promote the development of the industry, assuring your leading position in the whole market. Especially, the nonferrous metals industry is a collection of technology-intensive industries ：the speed and quality of its development in the future is not determined by how much natural resources you have but the soft resources such as knowledge and technology, depending on how innovative you can be and the extent you are applying them. The government should vigorously develop nonferrous industry professionals and scientists, establish institutes, conduct international exchange and cooperation. The enterprises also need to intensify research and development, strengthen independent innovation, and continuously develop their own brands to participate in the international competition.

6. FUTURE RESEARCH DIRECTION

The paper highlights two major research directions about china's nonferrous metal industrial competitiveness: one is the theoretical direction and another is empirical direction. In terms of theoretical direction, it is concluded in our paper that market competitiveness and benefit competitiveness play great role in the non-ferrous metal industrial competitiveness, which will give great highlight to the development of industrial competitiveness theory, so the next step may be develop a special industrial competitiveness evaluation theoretical model of nonferrous metal industry by adaptation from the Porters' diamond model with our empirical results. In order to obtain a comprehensive theoretical model, an empirical study on only one country is not yet enough, we need make comparison between different countries. As a result, in terms of empirical direction, it is necessary to choose European country or USA as objective to evaluate their nonferrous metal industrial competitiveness based on principal component analysis.

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