Factor Analysis of International Competitiveness of the Iron and Steel Industry in China

(Theme: Free trade and globalization, sustainable global product chains, clean products and production)

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Abstract

Iron and steel industry plays a vital role in the development of the national economy. In the past ten years, with the rapid development of China’s steel industry, China has gradually become one of the biggest centers of production, consumption and trade of iron and steel. However the international competitiveness and sustainability of Iron and steel industry in China are being doubted. During the revitalization of the Chinese steel industry, the problem of the iron and steel industry in China should enhance its international competitiveness and achieve sustainability in what way after the financial crisis needs to be answered.

On the basis of Porter’s competitive advantage theory, combined with China’s reality, this paper constructs a theoretical and analytical framework of the international competitiveness for China’s iron and steel industry; then employs econometric models to measure the factors which affect the international competitiveness of China’s iron and steel industry in the three aspects of production, consumption and trade. In the end, this paper discusses the potential influence of these factors on the sustainability of China’s iron and steel industry influence and proposes some policy recommendations for the development of China’s steel industry.

Keywords: iron and steel industry international competitiveness influence factors sustainability China

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1 Introduction

Iron and steel industry plays a vital role in the development of the national economy. In the past ten years, with the rapid development of China’s steel industry, China has gradually become one of the biggest centers of production, consumption and trade of iron and steel. China has been the biggest production center of crude iron and steel since 1996. China’s production share of the world reached 30% in 2006. Besides, China’s steel exports grew to 61,860,400 tons in 2007, which was 11.6 times than that in 1994. Though the Iron and steel industry in China has made great development and achievements, its international competitiveness has been questioned.

One of the main doubts is that the Chinese steel industry exports mainly low-end types of products such as steel bars and wire rod products whose characteristics are low technology content and low added value. The international competitiveness of iron and steel industry in China which comes from such low-end products will be possibly unsustainable. Thus, to explore the sustainability of the international competitiveness, it is necessary to analyze the factors which affect the international competitiveness of China’s iron and steel industry.

In addition, in 2008 the international financial crisis has brought a heavy blow to global steel industry and China's steel industry. Losses began to loom the whole iron and steel industry in China in October 2008. In response such serious impact on steel industry, on January 14, 2009, the State Council approved the adjustment of the steel industry revitalization plan, and clearly put forward to improve China’s iron and steel industry’s international competitiveness. So how to enhance international competitiveness and ensure sustainable development of iron and steel industry will be important issues in the process of revitalizing the steel industry.

The key points we concerned in this paper are two questions: What are the important factors that influence the development of the international competitiveness of China’s steel industry? How to take advantage of these factors to promote the sustainable development of the steel industry?

In the study of international competitiveness at industry level, Porter’s Diamond model is the classic paradigm. Most empirical studies on this topic usually employ Porter’s model and combined with specific cases to analyze the determinants of the industrial competitiveness.
Fagerberg (1995) used the 1965-1987 statistical data of 16 OECD countries to fit a regression model which based on the Porter’s model and the results showed that the factor of mature consumer’s decision had a strong positive impact on the international competitiveness of industries. Kim, D., and Marion, B. (1997) established an econometric model and used the U.S. food industry data for the year 1967-1987 to test the factors of domestic market structure and competition in the international competitiveness of an industry. Zengren Wang (2002) adopted revealed comparative advantage index and the overall labor productivity as indicators of the international competitiveness and did an empirical research on Chinese manufacturing industry. The results show that industrial concentration and technological innovation are the key factors of the international competitiveness of Chinese manufacturing industry.

There are two kinds of study for the steel industry’s international competitiveness. The first sort is to describe the international competitiveness by using a variety of indicators. Such as Yang Shu Qin (2007) designed a steel industry competitiveness evaluation index system which included industrial production, international trade capacity and industrial clustering ability to analyze the international competitiveness of the iron and steel industry in China. She reached a conclusion that China is a big but not a powerful center for the production of iron and steel. The second sort is to theoretically analyze the factors which would probably affect the international competitiveness of the iron and steel industry. Run Xuqian (2003) employed the Porter’s theory to analyze the determinants of the international competitiveness of the iron and steel industry in China and gave some policy recommendations for the improvement of the industry.

Overall, the current studys focus on the assessment of the international competitiveness of China’s iron and steel industry and theoretical analysis on the determinant factors. However, the quantitative analysis of the determinants of iron and steel industry in China is quite needed. So our paper will use factor analysis and econometric modeling method to explore the determinants of the Chinese steel industry’s international competitiveness in a quantitative approach.

Chapter two will establish a factor analysis framework for the international competitiveness of China’s iron and steel industry by combining the Porter’s theory with characteristics of China’s steel industry. Based on the factor analysis framework, Chapter three will employ an econometric model to make quantitative analysis. Then in chapter four we will analyze the results of the model and explore how to take advantage of these factors to promote the sustainable
development of the steel industry. Finally we get the conclusion and policy recommendations.

2 Theory and Method

2.1 Basic Theory

There are two main theories on the determinants of international competitiveness: one is the Comparative Advantage theory and the other one is the Competitive Advantage theory. Both of the theories are the important parts of international trade theory. But they are different in three ways. First of all, Comparative Advantage refers to relations among different industries, while Competitive Advantage concerns about the relations among countries involved in the same industries. Second, they have different starting point. Theory of comparative advantage arises from the formation and division of labor and mode of trade concerns and competitive advantage theory is developed from the competitive perspective. Third, the comparative advantage ultimately comes to a country's resource endowment and favorable conditions for industrial development, which emphasize on the potential for the development of national industry. And Competitive Advantage concerns about corporate strategy, which emphasizes the reality of situation of the development of national industry. Favorable conditions don not guarantee the international competitive advantage of an industry.

From the comparison between the two theories, competitive advantage is a more appropriate theoretical basis for the study of the international competitiveness of industries. Within the Competitive Advantage theory, Potter's Diamond model is the most wide-used and systematic one in research area. In recent years, scholars at home and abroad has tested and developed Potter's Diamond model by employing the theory in evidence study in different industries and countries. So we select Potter's national diamond model as an important theoretical basis for this study.

However, it will be biased to directly use of Porter's Diamond model for analysis. First, Porter's Diamond model focuses on the perspectives of management of science, economics theoretical tools for specific case studies. So the results are the qualitative description and induction and it is hard to determine quantifiable targets in this framework. Second, the
“national diamond” theory is based on the evidence of national competitiveness all over the world and draws the abstract theory from the evidence. So it does not include the specific characteristics of specific countries and industries.

Therefore, we choose Porter's "national diamond" model as the basic theory and combined with characteristics of China's steel industry to establish the factor analysis framework for the international competitiveness of China's iron and steel industry. So that we can explore the determinant factors in this framework by both qualitative and quantitative approaches.

### 2.2 Factor Analysis Framework

![Factor Analysis Framework](image)

As it is shown in the Factor Analysis Framework for the International Competitiveness of China’s Iron and Steel industry, industry competition in the international market is divided into three processes: competitive conditions and potentials, competition ability and competition result.

Competition potentials mainly rely on material conditions, support from related industries and industrial technology. Among them, the material conditions are determined by the country’s resources and factor endowments. And support from related industries such as transportation, provision of raw materials is very important for the growth of the industry. Industrial technology support is a vital aspect in competitive potentials. Powerful industrial technology can improve the industry's first production efficiency and gain an advantage in price when facing the same products’ competition in the international market. Besides, the increase the technical content will make
industrial products' quality more attractive when facing the same products with the same price in the international market.

Competitive conditions include domestic market structure and macroeconomic situation. According to Porter's National Diamond Theory, fierce market competition can improve the industry international competitiveness and macroeconomic situations are the opportunities for the industry development outside.

Competition ability mainly depends on the industry's production costs and international market prices. Those products with relatively low production costs have a more competitive advantage than others homogeneous products with relatively low production costs. Similarly, products with higher quality also gain competitive advantage in the international market and the prices are much higher than the same kind of products.

By definition, an industry's international competitiveness is the competitive abilities of a specific industry which reflect in production capacity, market share and trade capacity in the international market. Production capacity refers to the production efficiency; market share means the products' market share in the international market; trade capacity refers to the advantage in the international trade.

3 Model and Process

3.1 Factor Analysis Model

Based on the Factor Analysis Framework for the International Competitiveness of China's Iron and Steel industry in Chapter two, we can establish the Factor Analysis Model as below:

International competitiveness = F (potential competition, competitive, competitive)

For quantitative analysis, it is necessary to specify the abstract factors and select appropriate variables for the model. The international competitiveness of an industry refers to the competitive abilities which reflect in production capacity, market share and trade capacity shown in the international market. It is a comprehensive concept and it is hard to represent its meaning by a single indicator. China's iron and steel industry in the international market competitiveness reflected mainly in production capacity, market capacity and trade capacity in three aspects. As a
result, we establish three separate models and select corresponding variables for each one according to the Factor Analysis Framework.

1. Dependent variables

Production capacity of iron and steel industry mainly refers to the productivity. And we use the steel industry overall labor productivity as the dependent variable for the production model. Market power means the market share of the steel industry in the international market share. Specifically, it refers to the total Chinese exports of steel products accounted for the share of world steel exports. Trade capacity means the advantage reflected in the international trade market and a typically wide-used variable is TSC (Trade Specialization Coefficient).

2. Independent variable

(1) Production Model

Productivity is a stock index, which means the productivity of the previous period has impact on present period. So it is necessary to involve the lag variable in the production model. As a typical Capital-intensive industry, the capital intensity of the industry is a key factor for productivity. And we use per capita assets as an ivory variable for capital intensity. According to mainstream economics efficiency wage theory, labor productivity has a positive relationship with reward, that is, the higher the reward, its response to higher productivity of the labor force. Due to the difficulty of quantifying reward in some situations, we select the industry's average wage as an alternative indicator. Science and technology investment is a driving force for industry technology and technological development can contribute to improve productivity. Therefore, we choose scientific and technical personnel proportion of the input variables as the intensity of science and technology investment.

(2) Market Model

Generally speaking, industry's export market share is a stably change variable. The previous market share has possibly have relations with present one. And it is necessary to consider the lag variable in the market model. The competition in the international market within the same kind of products is mainly the price competition. So price is an important variable affecting market power. The structure of the domestic market reflects the extent of domestic market competition. In a fierce domestic market competition, companies may be prompt to perform better and better and go out to the international market. As a result, the industry's
competitiveness in international markets may be strong. Otherwise, in a weak domestic market competition, the international competitiveness of the industry may be weak. It is proper to choose industry concentration as a domestic market structure indicator for industrial concentration is a measure of the typical indicators of industry market structure. The development of the transport industry, especially the marine transportation development provides a good support for the competition in the international market, so we choose the port throughput as an indicator of the development of marine transportation.

(3) Trade Model

Trade Specialization Coefficient reflects the proportion of a certain industry's net exports to the total imports and exports of the industry in a country. It is jointly decided by the size of the import and export volume of the current year, domestic production and consumption, foreign production and consumption. Due to so many factors and large uncertainties, Trade Specialization Coefficient usually does not have lag feature. Support from related industries is important in the trade capacity of an industry. And material provision industries such as coke and maritime transport industry play key role in the realization of trade advantage in the international market. So we choose port throughput as an independent variable in the trade capacity model. Similarly, industry concentration and the average price of export products are also the important factors for trade capacity according to the Factor Analysis Framework.

From the analysis above, we can establish the following Factor Analysis Model for international competitiveness of China’s iron and steel industry:

Production Capacity: overall labor productivity = F (per capita assets, the industry average wages, the proportion of scientific and technical personnel)

Market power: the export market share = F (major port throughput, industrial concentration, the average price of exports)

Trade capacity: Trade Specialization Coefficient = F (major port throughput, the average price of export products, industry concentration, industry, coke consumption)

Correspondingly, Specific model forms are as follows:

\[ OLP = \alpha_0 OLP(-1) + \alpha_1 KL + \alpha_2 AW + \alpha_3 RD + \varepsilon \]  
\[ LOG(MS) = \alpha_0 LOG(MS(-1)) + \alpha_1 LOG(CR4) + \alpha_2 LOG(AP) + \alpha_3 LOG(PORT) + \varepsilon \]  
\[ NTB = \alpha_0 LOG(CR4) + \alpha_1 LOG(AP) + \alpha_2 LOG(PORT) + \alpha_3 LOG(COAL) + \varepsilon \]
3.2 Data

We estimate our three empirical models using a special data set for the iron and steel industry in China. This set includes annual data from 1990 to 2006 for the industry. The main data sources are "China Statistical Yearbook," "Statistical Yearbook of China Iron and Steel" and "China Statistical Yearbook". And all these datas related with price have been adapted by the Consumer Price Index to ensure all of them are comparable data among different years.

We briefly highlight certain features of our data set. In the time series Econometric Model, serial correlation is a majored problem concerned. So it is vital to make sure the datas are stable or have Cointegration relations.

In such approach, we take a look at the datas in the three models and find some problems. Take datas in production model for example. By observing the chart, we can easily find that most of the datas in the production model have obvious time series. Then we take the ADF test to prove the non-stationary of the data and the result is shown in Table 1 as below. From the ADF result, we can know that all the variables are non-stationary datas except the proportion of scientific and technical personnel. So it is necessary to take a Multivariate cointegration test such as JJ Test. Known by the test results, there is a cointegration between the variables relationship equation at 1% level significance. According to the coordination theory, although the data itself is not smooth, but long-term relationship exists between the datas. Therefore ols regression still can be used in this model.

<table>
<thead>
<tr>
<th>variable</th>
<th>Critical level</th>
<th>Critical value</th>
<th>ADF</th>
<th>Lag order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aw</td>
<td>1%</td>
<td>-2.7570</td>
<td>-3.337412</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>-1.9677</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KI</td>
<td>1%</td>
<td>-2.7411</td>
<td>-2.884876</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>-1.9658</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RD</td>
<td>1%</td>
<td>-4.6712</td>
<td>-4.376772</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>-3.7347</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OLP</td>
<td>1%</td>
<td>-2.7411</td>
<td>-2.733484</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>-1.9658</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3 Model Results

![Diagram of model estimation process]

We estimate our models in the process as shown in the Graph 2. The most important thing for estimation is to handle the time series problem properly. Though most of the variables in the three models are non-stationary data, variables in each model have cointegration relationships by taking Multivariate cointegration tests such as JJ Test. Therefore, OLS regression still can be used in this model.

As it is shown in the Table 2, the international competitiveness of China's iron and steel industry are determined by a series of factors. In the production model, KLOAWO (per capita assets and the industry average wages) and RD (the proportion of scientific and technical personnel) are significantly influence the production capacity which is represented by labor productivity. In the market share model, CR4 (industrial concentration), AP (the average price of exports) and PORT (major port throughput) are all significantly influence the market power which is represented by the export market share. In the trade capacity model, AP (the average price of export products), PORT (major port throughput), COAL (coke consumption) are significantly influence the trade capacity which is represented by Trade Specialization Coefficient.

Furthermore, RD (the proportion of scientific and technical personnel) is the key factor of the production capacity of the iron and steel industry in China; AP (the average price of exports)
and CR4 (industrial concentration) are the determinant factors of the market power of the industry; COAL (coke consumption) is the dominant factor of the trade capacity.

<table>
<thead>
<tr>
<th>Table 2 Results for variables in the production model</th>
<th>variable</th>
<th>Model result (OLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production capacity model</td>
<td>OLP</td>
<td>0.26* (0.0639)</td>
</tr>
<tr>
<td></td>
<td>KLOAWO</td>
<td>0.86*** (0.0000)</td>
</tr>
<tr>
<td></td>
<td>RD</td>
<td>21.20*** (0.0001)</td>
</tr>
<tr>
<td></td>
<td>MS(-1)</td>
<td>-0.048 (0.3388)</td>
</tr>
<tr>
<td>Market share model</td>
<td>CR4</td>
<td>0.54*** (0.0000)</td>
</tr>
<tr>
<td></td>
<td>AP</td>
<td>0.99*** (0.0000)</td>
</tr>
<tr>
<td></td>
<td>PORT</td>
<td>0.23*** (0.0000)</td>
</tr>
<tr>
<td></td>
<td>AP</td>
<td>0.67* (0.0573)</td>
</tr>
<tr>
<td></td>
<td>PORT</td>
<td>-0.82*** (0.0015)</td>
</tr>
<tr>
<td>Trade capacity model</td>
<td>PORT</td>
<td>2.00*** (0.0001)</td>
</tr>
<tr>
<td></td>
<td>COAL</td>
<td></td>
</tr>
</tbody>
</table>

*** means at the 1% critical level; ** means at the 5% critical level; * means at the 10% critical level.

4 Discussion

Science and technology investment is an important driving force for the industry and technological development can contribute to the improvement of industry productivity. Seen from the results of the production model, science and technology investment have a significantly positive effect on labor productivity. Besides, the iron and steel industry is a polluting industry. The development of production productivity probably will reduce the waste emission in the production process. So science and technology investment is a potentially positive factor for the sustainable development of the iron and steel industry in China. Industry average wage and per capita amount of capital jointly have positive impact on the industry productivity. However, it is hard to judge whether the two factors have good influence on the environment.
Domestic market structure usually has a negative impact on the international competitiveness of an industry. That is, the more intense the competition in the domestic market and the lower level of the market concentration, the stronger competitiveness the industry will show in the international market. But iron and steel industry is a typical industry which is characteristic of economies of scale. The increase of the market concentration can promote the effect of economies of scale and reduce the production cost. Thus the international competitiveness of the industry will be stronger in the international market. In this situation, the domestic market structure has a positive impact on the international competitiveness of the iron and steel industry. It is also this effect in the case of iron and steel industry in China. Furthermore, the potential effect of domestic market structure on the environment is usually positive. The higher degree of market concentration means bigger company and lesser small companies. In reality, a large number of small companies do much harm to the environment due to the low production capacity and the difficulty of environment monitor.

If the increase in average price of export products is due to improve the quality of products and the upgrade of the products structure, it will have positive effect on market share; if the increase in average price of export products comes from the low efficiency of production or high production cost, it will have negative effect on market share. Generally, both cases happen at the same time. In the market capacity model, the price factor has a positive effect on the market share. The result means the increase in the price mainly comes from the improvement of the quality of products and the upgrade of the products structure, which is consistent of the development of the iron and steel industry in China. In this situation, the increase of the price may have positive effect on the environment. Because the upgrade of the products structure and the improvement of the quality of products often can reduce the waste by using better technologies.

Transportation plays an important role in the realization of the international competitiveness. Convenient transportation especially the marine transport capacity give priority to the export of the products. It is also can not be ignored that the improvement of the marine transport capacity can increase the import at the same time. That is why the transportation has a positive effect on the market share and has a negative effect on the trade capacity.

Trade capacity model results show that the support from the raw material especially the
Coke play a vital role for the trade capacity of the iron and steel industry in China. Raw materials especially fuel resources are the material basis for the development of steel industry. The national resource abundance and geographical distribution has a major impact on production and distribution of the iron and steel industry. As seen from the development history of the world steel industry, most of the steel-producing countries are resource-abundant countries (except Japan). Coke is an important fuel and reducing agent required for the steel production. However, coke is also a material which causes huge environmental cost. The environmental pollution it causes in the production and refining process is particularly serious. The production of coke in China is mainly used for smelting iron and steel. The rapid development of the iron and steel industry in China in the past twenty years has stimulated the production and consumption of the coke. The price of the coke is much lower than that in other countries, which mainly due to the production cost of the coke does not include the environmental cost in China. Combined with the model results, the advantage of trade capacity of the Chinese steel industry comes from the low cost of raw materials such as coke, so it is not benefit for the sustainable development of the steel industry in China.

Table 3 the potential influence of the factors on the sustainability of China’s iron and steel industry

<table>
<thead>
<tr>
<th>Variables</th>
<th>the potential influence on the sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD</td>
<td>positive</td>
</tr>
<tr>
<td>KLOAWO</td>
<td>No direct influence</td>
</tr>
<tr>
<td>PORT</td>
<td>No direct influence</td>
</tr>
<tr>
<td>COAL</td>
<td>negative</td>
</tr>
<tr>
<td>AP</td>
<td>positive</td>
</tr>
<tr>
<td>CR4</td>
<td>positive</td>
</tr>
</tbody>
</table>

5 conclusion

On the basis of Porter’s competitive advantage theory, combined with China’s reality, this paper constructs a theoretical and analytical framework of the international competitiveness for China’s iron and steel industry; then employs econometric models to measure the factors which affect the international competitiveness of China’s iron and steel industry in the three aspects of
production, consumption and trade.

The model results show that RD (the proportion of scientific and technical personnel) is the key factor of the production capacity of the iron and steel industry in China; AP (the average price of exports) and CR4 (industrial concentration) are the determinant factors of the market power of the industry; COAL (coke consumption) is the dominant factor of the trade capacity.

Furthermore, factors such as industrial concentration, the average price of exports and the proportion of scientific and technical personnel have potentially positive effect on the sustainability development of the steel industry in China. And the huge amount production and consumption of the coke may have negative effect on the environment and the sustainability of the industry.

Reference


