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Technical Efficiency in China's Steel Industry at Firm-Level

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Abstract. China's steel industry has developed over last 60 years into the world biggest. China accounted for 36.4% of world steel production and 43.3% of world total consumption in 2007. It has driven by rapid modernization of its economy, construction, infrastructure and manufacturing industries. Maintaining and enhancing productive efficiency is a precondition for competitiveness of the Chinese firms in the current world market. In this project we use the firm level data of China's steel industry to measure the levels of technical efficiency at the year of 2007. We use the a grand frontier applicable to all firms and a group frontier specific to firms from any firm size and ownership type in order to evaluate and compare their efficiencies. The results of this project can be used to separately identify how firm size and proprietary of a firm affect its performance.

Introduction

China is the world's largest market for steel. The steel industry is gradually increasing and annual crude steel output was 100 million in 1996. It produced 123 million tons of steel in 1999. After its ascension to the WTO it aggressively expanded its production for its growing appetite of manufacturing industries such as automotive vehicles, consumer electronics and building materials. In 2009, China produced over 567 million tons of crude steel, which is 10 times the U.S. production, nearly half of the world's steel.

The Chinese steel industry is dominated by a number of large state-owned groups which are owned via shareholdings by local authorities, provincial governments and even the central authorities. The Chinese steel industry is highly fragmented, with more than 3,000 steel producers, which makes the domestic market highly competitive and difficult to control. Its growth also faces constraints such as dependence on imported iron ore and high energy consumption. The Chinese government has shown interest in stepping up its efforts to rein in steel overcapacity and to consolidate and restructure the steel industry (Tang, 2010).

The objective of this paper is to measure technical efficiency of Chinese steel firms for the year of 2007. We describe the non-parametric methodology of Data Envelopment Analysis (DEA). We also use the concept of a meta frontier production function introduced by Hayami (1969) and Hayami and Ruttan (1970, 1971) to examine whether technology varies among different firm size and ownership of steel industry.

In this paper we use firm level data from National Audit Department of China of the Chinese steel industry firms. The annual data are used to construct a meta frontier as well as separate group frontiers for firms classified by firm size and type of ownership. This permits us to examine the proximity of any group frontier to the meta frontier and measure such proximity by what we define as the technology closeness ratio (TCR) of the group. We can also evaluate the relative performance of each individual firm with constraints faced by all firms within the same group.

The DEA Models

The non-parametric method of DEA introduced by Charnes, Cooper, and Rhodes (1978) and further generalized by Banker, Charnes, and Cooper (1984) requires no parametric specification of the

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production frontier. In the multiple-output multiple-input case, with the assumptions of convexity of the production possibility set and along with free disposability of both outputs and inputs, the production possibility set can be constructed as the following (Bhandari and Ray, 2011):

$$T = \{(x, y): x \geq \sum_{j=1}^{N} \lambda_j x^j;\ y \leq \sum_{j=1}^{N} \lambda_j y^j;\ \sum_{j=1}^{N} \lambda_j = 1;\ \lambda_j \geq 0; j = 1,2,\dots,N\} \quad (1)$$

Where (x^j, y^j) is the observed input and output bundle of an individual firm *j* in a sample of *n* firms in the dataset.

For a nonnegative vector of quantities of both inputs and outputs, an input-output bundle (x, y) is feasible when the output bundle y can be produced from the input bundle *x*. The set of all such feasible input-output bundles constitutes the production possibility set *T*:

$$T = \{(x, y): y \text{ can be produced from } x; x \geq 0; y \geq 0\} \quad (2)$$

In the single output case, the frontier or the graph of the technology is defined by the production function *g(x)* representing the maximum quantity of *y* that can be produced using the input bundle *x* (Bhandari and Ray, 2011):

$$g(x) = \text{maximum value of } y, \text{ given } x, \text{ where } (x, y) \quad (3)$$

The corresponding production possibility set is:

$$T = \{(x, y): y \geq g(x); x \geq 0, y \geq 0\}. \quad (4)$$

The most efficiency way to measure the technological heterogeneity across different groups is to construct different group frontiers of each individual group and compare with a single grand frontier which applies to all firms. In order to construct the group production possibility sets, we need to firstly separate all observed bundles by criterions like firm size, location and ownership type.

Data and data Description

In this study, we use firm-level data of China's steel industry at the year of 2007. Each observation in our dataset includes the information on a number of variables for different individual industrial units covered by National Audit Department of China (NADC). Here, we conceptualize a 1-output, 3-input technology and chose one output and three inputs from the dataset. The output is Industrial output (prices at 2007), and the inputs are Number of Employees, Fixed assets and Material cost. Table 1 indicates the data variables, period, size and sources.

Table 1 Data inventory

Variables	Period	Size	Source
Annual total revenue	2007	4347 Firm-level data	NADC
Total assets	2007	4348 Firm-level data	NADC
Industrial output	2007	4349 Firm-level data	NADC
Total sales value	2007	4350 Firm-level data	NADC
Number of employees	2007	4351 Firm-level data	NADC
Fixed assets	2007	4352 Firm-level data	NADC
Ownership	2007	4353 Firm-level data	NADC
Total profit	2007	4354 Firm-level data	NADC
Material cost	2007	4355 Firm-level data	NADC
Other cost	2007	4356 Firm-level data	NADC
Location	2007	4357 Firm-level data	NADC
Firm size	2007	4358 Firm-level data	NADC
R&D expenses	2007	4359 Firm-level data	NADC
Advertisement	2007	4360 Firm-level data	NADC

*NADC: National Audit Department of China

Results

In order to perform a meta frontier analysis for studying the effects of difference in firm size, we focus in three major type. They are large, medium and small size firms. Observations from each size contribute to the construction of the meta frontier. Similarly, we consider four types of ownership: national, group owned, private, and foreign owned. There are 86.3 percents of firm in the dataset are under private ownership and nearly 2.3 percents of the total firms are under national ownership in the year 2007.

Average technical efficiency measured relative to both grand and group frontier as well as TCR for different firm size is shown in Table 2. The result shows that large firms had the highest grand technical efficiency. However, for large firms, there are relatively few of the firms in the dataset. Coming to the group efficiency, the technical efficiency measured by the ownership group frontier is found to be the best performing with the private ownership type.

As the firm size decrease from large to small, the grand technical efficiency is also decreasing. At the mean time, the private firms' TCR are both higher than 90 percents, which mean that the group frontier of private ownership at those two firm size are quite close to the grand frontier. It is evident from Table 2 that there are significant differences when firms are classified into different group in term of firm size and ownership. In order to accurately measure the impact of different category on the technical efficiency, a regression model need to be introduced and used to estimate the related parameters.

Table 2 Results of technical efficiencies under different models

Firm size	Criterion	National	Group	Private	Foreign
Large (113)	No. of firms	27	8	68	12
	Grand TE	0.7996	0.7996	0.7996	0.7996
	Group TE	0.9125	0.9748	0.811	0.963
	TCR	0.8763	0.8203	0.986	0.8303
Medium (449)	No. of firms	27	20	365	40
	Grand TE	0.3969	0.3969	0.3969	0.3969
	Group TE	0.7854	0.5244	0.5923	0.6251
	TCR	0.5054	0.7568	0.6691	0.6349
Small (3653)	No. of firms	40	167	3214	238
	Grand TE	0.18	0.18	0.18	0.18
	Group TE	0.5712	0.5831	0.1873	0.4541
	TCR	0.3151	0.3087	0.961	0.3964

Conclusion

In this study, we measure the levels of firm's technical efficiency from China's steel industry in the year of 2007. Our study is aimed to separately identify the contribution of technical efficiency across different groups. There is considerable room to increasing the outputs without increase the input bundles. This is helpful to lower the average cost of production in China's steel and steel processing industry and to increase the competitive of china's firms in the world market.

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