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Re-estimation of firms' total factor productivity in China's iron and steel industry ☆

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ABSTRACT

Using the firm-level census data, this paper re-estimated the total factor productivity (TFP) of firms in China's iron and steel industry and examined its potential determinants over the period 1998–2007. To deal with the "endogenous input" problem, we used the semi-parametric regression techniques for estimating the firm-level TFP. The results suggest that firms' TFP in China's iron and steel industry has been steadily increasing over time with the key drivers of productivity improvement differing substantially between firms with different characteristics including their size, ownership type and geographical location. Notably, the productivity of small firms is positively related to market share and negatively related to R&D. Large state-owned enterprises' productivity is relatively insensitive to changes in market share and R&D, while the non-state owned enterprises are more likely to obtain their productivity gains through export. Increasing firm size is generally positively correlated to firms' performance in TFP, and it is more so in the less developed Western than the Eastern and Central regions. The findings suggest that different policy instruments targeting firms with different characteristics in the process of restructuring the industry may be desirable.

1. Introduction

The rapid expansion of China's iron and steel industry (hereafter "the industry") since the early 21st century has been remarkable in terms of both the speed and scale of its development. Yet there is an issue regarding the "quality" of the industry's expansion as to whether the rapid growth was driven primarily by increases in inputs or gains in productivity. There is no consensus as to which factors have been more important for driving the ongoing wave of the industrial expansion which underscores the current resource boom. However, a more sustainable and healthy development of the industry should be based on continuing firm-level productivity growth — a representation of both the technological progress and efficiency improvement. Examining the change of firm-level productivity and its determinants over the past decade therefore becomes an important empirical question.

There have been many attempts made to quantify productivity of China's iron and steel firms and its determinants by using micro-economic (or firm-level) data. Jefferson (1990) was the first to estimate firms' total factor productivity (TFP) for the industry by using a log-linear production function with the cross-sectional data from 120 large- and medium-sized enterprises (hereafter LMEs) in 1986. Kalirajan and Cao (1993) and Wu (1996) adopted the stochastic frontier analysis to distinguish between firms' technical efficiency and their technological progress using the cross-sectional and panel data of LMEs covering the periods up to the 1990s respectively. Zhang and Zhang (2001) examined the technical efficiency of China's iron and steel firms in

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the 1990s using the data envelop analysis and Ma, Evans, Fuller, and Stewart (2002) and Movshuk (2002) focused on the ownership reform undertaken in the late 1990s and its consequent impact on firms' TFP in the industry.

These studies provided important insights in looking at the changes in firms' productivity in the industry and its determinants in the 1990s. However, these studies provided quite different results with respect to whether the industry's productivity and/or efficiency had increased or not over the periods under study. For example, Zhang and Zhang (2001) found that the average technical efficiency of China's iron and steel firms has been increasing in the 1990s while Ma et al. (2002) and Movshuk (2002) found the contrary results.

There are three possible explanations relating to both the methodological and data issues for this inconsistency. The first is that studies estimating productivity via the stochastic frontier method (or the data envelope analysis method) identify technological efficiency by assuming that best performed firms are at the production frontier. This assumption is likely to generate the results that are sensitive to sample choices. The second is that LMEs (usually state-owned) were dominant across all samples used by previous studies (due to data availability). This means that some important information on the prolific small and private enterprise (hereafter SE) sector is excluded from these studies. The third is that by utilizing data covering the period from the late 1980s to the late 1990s, when many reforms such as corporate restructuring and ownership reform in the industry had not been fully implemented, or were yet to bear fruit, thus these studies might not fully capture the fundamental changes resulting from economic reforms which underscore the micro-foundation for the improved firms' performance. Due to these factors, it may not be surprising that the earlier studies generated ambiguous results with respect to the impact of reform on industry productivity.

This paper applies the newly developed econometric techniques to re-estimate Chinese iron and steel firms' TFP by using an updated firm census data over the period 1998–2007. The approach adopted here includes the two-step method applied by Olley and Pakes (1996) and Levinsohn and Petrin (2003) and the GMM method proposed by Ackerberg, Caves, and Frazer (2006) and Wooldridge (2009) for estimating the industry's production function with the gross output assumption. These methods overcome the "simultaneity bias" between capital usage and unobserved productivity changes caused by the assumption of exogenous inputs (i.e. capital) that plagues traditional analysis (Olley & Pakes, 1996). As to the data, we believe that the census data for Chinese manufacturing industry is the most recent vintage ever incorporated into a study of this type.

Three questions are to be addressed. First, how has firm-level productivity in the industry changed over time? Second, what are the major driving forces behind firm-level productivity growth in the industry over the past decade? Third, are there any significant differences in productivity growth between firms with different characteristics such as firm size, ownership type and geographical location? Answers to these questions may show that productivities of firms of different types in the Chinese iron and steel industry are not only different over the period under the study, but also responsive to different reform measures undertaken in the industry. If that is the case, the findings may imply that further improvement in productivity and quality of the Chinese iron and steel industry may be enhanced by different policy instruments targeting firms with different characteristics in the process of restructuring the industry.

The remainder of the paper is arranged as follows. Section 2 briefly describes the development of China's iron and steel industry over the reform period. Some key factors associated with changes in firms' productivity in the industry, such as marketization reform, government sponsored investment and intensified competition, have been addressed. Section 3 presents the model specifications and the two-step approach for estimating firms' TFP, followed by a proposed regression for identifying its determinants. The semi-parametric TFP estimation techniques and the related literature are highlighted for their role in dealing with the problem of "endogeneous input choice". Section 4 discusses the estimation results and Section 5 concludes.

2. China's iron and steel industry and its microeconomic performance

While China' iron and steel industry grew along with the rest of the economy in the first decade of the reform era beginning in the late 1970s, it was not until the early 1990s that the sector began to expand at a remarkable rate in responding to the rapidly growing demand for steel products. During the period 1990–2007, China's production of iron ores, pig irons and crude steels have increased from 179 million tonnes (mt), 62 mt and 66 mt to 582 mt, 404 mt and 422 mt, representing average annual growth of 7.6%, 12.4% and 12.3% a year respectively. China's output of iron ores and crude steels rose to above one third of the global total, while its pig iron output rose closer to one half of world production over the same period. The rapid expansion of output in the industry has been accompanied by a significant industrial structural adjustment, characterized by a substantial increase in the number of enterprises and an enlargement of scale at individual firm level. The total number of firms in the industry increased from 1589 in 1990 to 11,596 in 2007 while the average real output value per firm (at 1990 constant price) increased from US$17.2 million in 1990 to US$32.5 million in 2008.[1] As a consequence, competition among firms in the industry has been intensified and firms' productivity has also increased rapidly over time. Fig. 1 shows the positive relationship between the real output value of China's iron and steel industry (at 1990 constant prices) and its average labor productivity between 1985 and 2007.

There are three factors that seem most relevant for assessing the rapid increase of firms' productivity. First, marketization reforms rendered more autonomy to enterprises (especially to SOEs) thereby helping to increase their production efficiency. Second, the rapid increase in fixed investment and the associated boost to average production capacity have helped to foster

[1] Ma et al., (2002) outline the increasing trend in the enlargement of existing firms' scale.