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An analysis on technical efficiency in post-reform China

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ABSTRACT

This paper employs a fully nonparametric stochastic frontier model with time and individual effects to study technical efficiency in China's post-reform economy. The panel data cover China's thirty provinces for the period of 1985–2008. The empirical results show that the average output elasticity of labor is larger than the other two inputs of capital and human capital. Based on the specified inefficiency Tobit model, the factor analysis on technical efficiency shows that the time effects of technical efficiency in China's post-reform economy are significantly contingent on the factors. There exists significant regional differences in technical efficiency in China's economic development, and a number of policy implications can be drawn.
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1. Introduction

The discussion on the sustainability of economic growth in China's post-reform economy has led to studies on China's productivity, using either growth accounting or stochastic frontier analysis (SFA) (Borensztein & Ostry, 1996; Chen, Yu, Chang, & Hsu, 2008; Chen, Huang, & Yang, 2009; Hu & Khan, 1997; Mao & Koo, 1997; Woo, 1998; Wu, 2000, 2003, 2004; Yang & Lahr, 2010). For example, the studies by Chow and Li (2002) and Li (2003) used investment figures to construct capital stock to estimate China's national total factor productivity (TFP) growth rates have been extended by Liu and Li (2006) and Li (2009) who incorporated the human capital variable and alternative investment data to examine both national and provincial TFP growth rates. Similar studies by Wang and Yao (2003) have examined the sources of China's economic growth, while Swamy (2003), Motohashi (2007) and Bosworth and Collins (2008) have compared China's TFP with other world economies.

In studying the technical change in the United States, Solow (1957) differentiated the movement along the production function caused by input growth from shift in the production function caused by technical progress. Both Bauer (1990) and Kumbhakar and Lovell (2000) have shown that TFP growth composes of technical progress, technical efficiency change and a scale economies effect. In theory, technical progress is an outward shift of the production frontier and technical efficiency change shows the movement from a position within toward a position on the production frontier, while the scale economies effect reflects an increase in return to scale.

Other studies have elaborated and extended China's post-reform economic productivity to efficiency analysis by using the Malmquist productivity index (MPI) and data envelop analysis (DEA) (Wu, 1995, 2008). The MPI that decomposes productivity

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into efficiency and technological change has also been applied in Ma, Evans, Fuller, and Stewart (2002) and Movshuk (2004). Studies on the productivity and efficiency performance of individual industries in China have been conducted by Jefferson (1990) and Mu and Lee (2005), while Yao, Han, and Feng (2007) and Sun, Hone, and Doucouliahgos (1999) agreed that SFA and DEA are the more effective approach to measure the technical efficiency of industries. The SFA used in studies on the China's economy have provided useful implications on the production function and technical efficiency performance (Brummer, Clauben, & Lu, 2006; Fu, 2005; Hu & McAleer, 2005; Huang & Kalirajan, 1998; Kalirajan, Obwona, & Zhao, 1996; Tong, 1999; Wu, 2000, 2003).

Nonetheless, studies on China's post-reform economy have provided a continued debate on whether technical progress or technical efficiency is the more important contributing factor to China's TFP growth (Li & Liu, 2011; Wu, 2000). After more than three decades of economic reform since 1978, it would be useful to examine if technical efficiency has become an important factor in China's growth. In addition, an objective measure on the technical efficiency among China's provinces is crucial. Given the extraordinary nature, the heterogeneity of development in various regions and different time periods, a flexible stochastic frontier model can be used to study technical efficiency in the post-reform China's economy.

Empirical studies using the conventional stochastic frontier analysis on panel data models often implicitly impose a restriction that information differences have no effect on the way risk-neutral decision makers utilize the same input bundle (Christopher, O'Donnell, & Chambers, 2010). The result is that informational differences are mistaken for differences in technical efficiency. The two specific effects that reflect information differences are the individual effects and the time effects. They are usually specified in stochastic frontier models in the manner that individual effects are time-invariant and do not interact with time effects, often in linearity or in parametric forms. However, when the individuals in the sample differ in technology and efficiency with differenced information, especially when such heterogeneity changes with time, the linear or parametric specification cannot fully describe the heterogeneity in the production function and may induce a bias in the measurement of technical efficiency. Conventional methods (either DEA or SFA) attribute the model misspecification errors to inefficiency (Balaguer-Coll, Prior, & Tortosa-Ausina, 2007; Battese & Coelli, 1992, 1995; Fu, 2005; Grösche, 2009; Joseph, Sandra, & Zhu, 2010; Kumbhakar & Lovell, 2000; Wu, 2003). Researchers have relaxed distributional assumptions in the error component and parametric assumptions in SFA to achieve a more reliable measurement of technical efficiency (Greene, 2005; Henderson & Simar, 2005; Kneip & Simar, 1996).

The data set used in this study contains the thirty provinces in China for the period from 1985 to 2008. One can note that China during the sample period has experienced a systemic transition with heterogeneity of provinces and development periods. The regional effects and time effects should be given sufficient attention in measuring the technical efficiency of the economy. This paper provides a time-variant estimation of technical efficiency in China's post-reform economy by specifying and estimating a fully nonparametric stochastic frontier model with nonparametric individual and time effects (Henderson & Simar, 2005). A factor analysis on technical efficiency by using the Tobit regression will also be conducted.

Section 2 specifies the nonparametric model and presents the estimation method. Data and variables specification are illustrated in Section 3. Section 4 presents the empirical results of the frontier model and the measurement of the technical efficiency. Section 5 provides the specification test to show the suitability of the nonparametric model. Section 6 provides a factor analysis on the technical efficiency based on the Tobit estimation. Section 7 concludes the paper.

2. Fully nonparametric model specification

The studies in Gong and Sickles (1992) and Christopher et al. (2010) show that the estimates of technical efficiency for the parametric panel data frontier model can be improved when the production function model is closer to the true underlying technology. In practice, the data generating process is unknown and so are the stochastic factors in the economic data. Hence a flexible model specification will give a more reliable result on frontier and efficiency estimates. In our sample period, production technology and efficiency in China has experienced uneven development among different provinces. A fully nonparametric stochastic model can thus give reliable technical efficiency estimates. We specify the nonparametric stochastic frontier model as follows:

$$y_{it} = f(x_{it}, i, t) + u_{it}, \quad i = 1, 2, \cdots, n; \; t = 1, 2, \cdots, T \tag{1}$$

where y_{it} is the logarithm of real gross regional product (RGRP) for province i in year t; x_{it} is the vector of the logarithm of the three inputs: capital (K), labor (L) and human capital (HC); $f(x, i, t)$ is the production function which is allowed to vary over each province and time period, and is nonparametric with input variables x, individual effects and time effects; u_{it} is the error term independent of x_{it}. As we know, human capital may have an impact on production through both direct and indirect channels (Barro & Sala-i-Martin, 1999; Benhabib & Spiegel, 2005; Vandenbussche, Aghion, & Meghir, 2006). Equally, the human capital embodied in the labor force can exert a direct and an indirect influence on aggregate production through technological innovation, imitation and adoption. Given that the impact channels are uncertain, it would be appropriate to allow human capital to enter the production function and interact with capital and labor inputs, individual and time effects in a nonparametric manner.

Model (1) can be estimated using the approach in Henderson and Simar (2005). Denote $\beta(x, i, t)$ as the first derivative of $f(x, i, t)$ with respect to x. By the Taylor expansion,

$$y_{it} = f(x, i, t) + (x_{it} - x)\beta(x, i, t) + o(|x_{it} - x|) + u_{it}, \tag{2}$$

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