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Efficiency and technology gap in China's agriculture: A regional meta-frontier analysis

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Abstract

This paper utilizes a unique county-level dataset to examine technical efficiency and technology gap in China's agriculture. We classify the counties into four regions with distinctive levels of economic development, and hence production technologies. A meta-frontier analysis is used. We find that although the eastern counties have the highest efficiency scores with respect to the regional frontier but the northeastern region leads in terms of agricultural production technology nationwide. Meanwhile, the mean efficiency of the northeastern counties is particularly low, suggesting technology and knowledge diffusion within region might help to improve production efficiency and thus agricultural output.

JEL classification: D24; N55; O13
Keywords: China's grain production; County-level; Meta-frontier; Stochastic production frontier; Technical efficiency

1. Introduction

The increasing demand for grain in China due to income and population growth has invited debates on how well China can feed its population in the future. The extant literature has seen a great deal of discussions on whether viable options remain for increasing agricultural production in China. The role of technical and allocative efficiency was investigated in Chen and Huffman (2006), Mao and Koo (1997), Wang, Cramer, and Wailes (1996), and many others (see, also, a discussion in Abdulai & Huffman, 2000).

Many of the aforementioned studies have used micro-level data sets. Estimates derived from aggregate datasets may produce different results and, hence, different policy implications (Carter, Chen, & Chu, 2003). Studies based on

Abbreviations: GVAO, Gross Value of Agricultural Output; LP, Linear Programming; OLS, Ordinary Least Square; QP, Quadratic Programming; SSB, State Statistical Bureau; TE, Technology Efficiency; TGR, Technology Gap Ratio; SPF, Stochastic Production Frontier.

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aggregate statistics could derive inferences and recommendations about regional policies. Provincial statistics of China have been extensively used, see, e.g., the influential paper of Lin (1992) on household responsibility system, and Fan and Zhang (2002) on productivity and inequality. On the other hand, Herrmann-Pillath, Kirchert, and Pan (2002) argue that provincial aggregation might not reflect the exact regional inequality of development for China and propose to use prefecture-level data. Chen and Huffman (2006) use county-level dataset to investigate patterns of technical efficiencies in China's agriculture. Meanwhile, an important feature of agricultural production, namely regional variation, arises when aggregate statistics are used. With a size similar to that of the United States and spanning from frigid to torrid zones, China displays significant geographical variation, i.e., soil quality, climate, precipitation, and pests, across the country. Yang (1996) finds that for respective crops, factor productivities are generally higher in the major producing areas than those in the fringe areas, likely due to more suitable natural conditions and higher level of specialization. The economic institutions and levels of economic development also vary across China, e.g., see Krusekopf (2002) for a discussion of the diversity in land tenure arrangements.

To further understand the impact of regional variation on the estimation of efficiency in agricultural production, it is desirable to examine how agricultural production technologies differ across regions. Production frontiers may shift due to variation in farming technologies and economic institutions. Therefore, traditional efficiencies operating under a common production frontier are not comparable with those operating under different production frontiers.

Recent regional studies suggest that there are four grand regions in China, i.e., Northeast, East, Central, and West, differing from each other in geography, natural endowment, and most importantly, the level of economic development.[3] Ignoring the variation across the regions could lead to biased estimates of the frontier production function and efficiency scores, and hence misleading policy implications. The objective of this paper is to provide new evidence on production efficiency and technology gap in China using a meta-frontier methodology based on a unique county-level data set in 1999. A meta-frontier methodology is an overarching function that encompasses the deterministic components of the stochastic frontier production functions operating under the different technologies involved (Battese, Rao, & O'Donnell, 2004). The model enables the calculation of comparable efficiencies and estimation of technology gaps for production under different technologies relative to the potential technology available to the economy as a whole.

The rest of this paper is organized as follows. Section 2 formulates the econometric modeling strategy. Section 3 describes the data. Section 4 presents the empirical findings. The last section concludes.

2. Econometric methodology

The goal of our analysis is to assess how efficient China's counties are in their agricultural production using a recently developed variant of stochastic production frontier model, which dates back to Meeusen and van den Broeck (1977) and Aigner, Lovell, and Schmidt (1977).

A stochastic frontier model assuming a truncated normal distribution of the non-negative random term can be expressed as: $Y_i = f(x_i,\beta)\ e^{(V_i - U_i)}$, $i = 1,\ldots,N$, where Y_i is the output (or its natural logarithm) of the i-th county; x_i is a $k\times 1$ vector of the input quantities (or their natural logarithms) of the i-th county; β is a conformable parameter vector. V_is are the random disturbance terms that are assumed to be i.i.d. $N(0,\sigma_v^2)$. They are incorporated in the model to reflect the random disturbance that is independent of U_is, which are non-negative random terms that represent technical inefficiencies in production. They are assumed to be i.i.d. and truncated at zero of the $N(\mu,\sigma_u^2)$ distribution. The relationship between U_i and the output-oriented technical efficiency (TE) is $TE^i = \exp(-U_i)$.

To accommodate the potential regional variation of agricultural production frontiers and obtain comparable technical efficiencies for the counties, the meta-frontier analysis proposed in Battese et al. (2004) is used in this study. The meta-frontier production function is a frontier function that envelops all frontiers of individual regions/groups. Fig. 1 presents an illustration of a simple case with one input. At a given input bundle, the technology gap ratio (TGR) is defined as the highest possible output within the region divided by the highest possible output at the meta-frontier. The technical efficiency relative to the meta-frontier is defined to the real output of a county divided by the highest possible output at the meta-frontier. The meta-frontier can be estimated by finding a function that best envelops the

[3] Expert opinions have resulted statements regarding regional economic development in Chapter 19–20 in the National Economic and Social Development Eleventh Five-year Plan, see e.g., http://politics.people.com.cn/GB/59496/4208570.html.