



## Full length article

# Examining the economic performance of Chinese farms: A dynamic efficiency and adjustment cost approach

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## ABSTRACT

To understand the state of adjustment processes and the dynamic structure in Chinese agriculture, this paper proposes a dynamic frontier-based model using the shadow cost approach. For this purpose, a dynamic duality model framework of inter-temporal decision making is used. Using a panel data set of 4,201 Chinese farms from three provinces (i.e. Zhejiang, Hubei and Yunnan) from 2003 to 2006, this is the first study to investigate the allocative and technical efficiencies of Chinese agriculture using a dynamic shadow cost approach. The findings show that the adjustment of quasi-fixed inputs is rather sluggish, implying that adjustment costs are considerably high on Chinese farms. The relatively low levels of allocative and technical efficiencies indicate that most farms are unable to catch up with the production frontier under the existing production technology. They are also unable to use various inputs in the appropriate proportion given their respective prices.

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## 1. Introduction

China's agricultural development has been remarkable over the past four decades. Rural reforms that began in the late 1970s improved farmers' incentives and had a huge impact on China's agricultural productivity growth and output. The value of agricultural output increased enormously, from 139.7 billion Chinese yuan in 1978, to 10,222.6 billion yuan in 2014.<sup>1</sup> Agricultural total factor productivity (TFP) has also grown fast—by 4% per annum on average from 1979 to 2008 (Zhang and Brümmer, 2011). The great achievement of China's agricultural production has so far come almost entirely from smallholder farming, represented by about 200 million small-scale farms.

Despite great successes, many challenges remain or have even increased over the last decade. For instance, the continued rising opportunity costs of agricultural labour will lead to the gradual loss of China's competitive labour advantage. Further, household rights to land are still incomplete after several waves of land tenure reforms (Ma et al., 2015). This induced land insecurity reduces the incentives of farmers to make productivity-enhancing investments in land (e.g. irrigation, drainage, terracing and the application of organic fertilizer), and hinders the efficient use of labour (Brandt et al., 2002; Deininger and Feder, 2001), as a result decreasing agricultural productivity.

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<sup>1</sup> The statistics are taken from China Statistical Yearbook 2015, National Bureau of Statistics of China.

China's major agricultural policy objectives have been consistent in their aims to increase grain production capacity to largely ensure food self-sufficiency and at the same time improve farmers' income. Since 2004, the No. 1 Documents<sup>2</sup> of each year have concentrated on issues related to agriculture, farmers and the countryside (the so-called 'three nongs'). In recent years these documents have focused on investments in agricultural technology to boost production and the adjustment of farm structure, emphasizing a transition to larger-scale farms (OECD, 2013, 2015). In this context, the role of adjustment costs and dynamic cost structure are becoming important issues for investigating performance in Chinese agriculture. Whether adjustment costs are significant and whether they can be regarded as a source of the sluggish adjustment processes are of interest to policymakers. Considering the major challenges in Chinese agricultural production, the extent to which Chinese farms could perform better remains an important research question. A measure of cost efficiency and its decomposition provides an indicator that measures the exploitation of resources (technical efficiency) in Chinese agriculture, as well as an indicator that characterizes the economic losses due to suboptimal allocation of resources (allocative inefficiency). Furthermore, this study addresses the issue by characterizing the cost structure of Chinese farms under dynamic adjustment, to measure their performance.

The frontier approach has become the state-of-the-art for analysing the performance of firms in the literature. Modern efficiency and productivity methodologies measure firm performance relative to best-practice frontiers. Both parametric and nonparametric techniques have been continuously developed to identify the best-practice frontier. Recent empirical studies that have conducted the frontier-based model using both parametric and nonparametric techniques to measure firms' efficiency and productivity in various industries include Lee et al. (2017), Johnstone et al. (2017), Fujii and Managi (2017) and Tamaki et al. (2017).

Frontier-based models using a parametric approach to estimate firm efficiency have been an important area of research, which has been continuously developed for more than half a decade. Following the pioneering work of Aigner et al. (1977) and Meeusen and van den Broeck (1977), the frontier analysis model has been employed for both primal and dual representations of production technologies. With the availability of input quantity and cost share data, a dual cost frontier approach allows researchers to estimate and decompose the firm's cost efficiency into technical and allocative efficiencies. Analysis of the cost frontier models has further grown with important contributions by many researchers (Schmidt and Lovell, 1979; Kopp and Diewert, 1982; Zieschang, 1983; Bauer, 1990; Greene, 1993; Kumbhakar, 1997; Maietta, 2000; Atkinson and Primont, 2002; Assaf and Matawie, 2008). However, the cost frontier models presented in these studies were developed in a static context. The shortcomings of the static frontier-based model include ignoring the explicit role of time and how the adjustment of quasi-fixed inputs to the observed long-run level takes place. As a result, efficiency scores measured from the static efficiency model may be inaccurate and misleading. The absence of an explicit analysis of the transition path of quasi-fixed factors toward their desired long-run levels can be remedied by explicitly incorporating the costs of adjustment for the quasi-fixed factors. The framework of the optimal inter-temporal behaviour of the firm using the notion of adjustment costs as a means of solving the firm's optimization problem was first introduced by Eisner and Strotz (1963). The theory of inter-temporal duality was improved upon by McLaren and Cooper (1980a) and Epstein (1981). This theory represents an alternative and powerful method for solving inter-temporal optimization problems by using the optimal value function of the dynamic programming equation (DPE) approach. This field has further grown with important contributions by many researchers (i.e. Vasavada and Chambers, 1986; Howard and Shumway, 1988; Luh and Stefanou, 1991, 1993; Fernandez-Cornejo et al., 1992; Manera, 1994; Pietola and Myers, 2000; Sckokai and Moro, 2009). Though the static efficiency model and the dynamic duality model of inter-temporal decision making have been continuously developed, they have moved in separate directions. Recently, Rungsuriyawiboon and Stefanou (2007) formalized theoretical and econometric models of dynamic efficiency in the presence of inter-temporal cost-minimizing firm behaviour. The dynamic efficiency model is developed by integrating the static production efficiency model and the dynamic duality model of inter-temporal decision making. The dynamic efficiency model defines the relationship between the actual and behavioural value function of the DPE for a firm's inter-temporal cost minimization behaviour. Therefore, the dynamic efficiency model provides a system of equations that allows the measurement of both the technical and allocative inefficiency of firms.

Other studies of Chinese agricultural performance have relied on conventional approaches and employed static frontier-based models (Brümmer et al., 2006; Wang et al., 2012; Zhang et al., 2011). In addition, given that these studies mostly investigated the performance of Chinese farms based on different data sets and time periods, it goes without saying that a cross-study comparison is precluded by the lack of a common basis. Brümmer et al. (2006) use a distance function approach with farm household data in the Zhejiang Province for the period 1986–2000, and the results show that the level of technical efficiency range from 0.326 to 0.878. Zhang et al. (2011) apply a two-stage model with a panel data set containing households from Zhejiang, Hubei and Yunnan to analyse the impact of land reallocation on farm production, and the estimated level of technical efficiency is relatively high, with average scores of 0.96, 0.91, and 0.87, respectively. Within a meta-frontier framework, Wang et al. (2012) provide evidence that technical efficiency is significantly affected by farm heterogeneity and that farming technology exhibits region-specific characteristics.

To fill these gaps, the main purpose of the study is to understand the state of adjustment process and dynamic structure in Chinese agriculture. To meet this goal, our paper extends the model of Rungsuriyawiboon and Stefanou (2007) into a more general context with a multiple quasi-fixed factor case. The dynamic efficiency model is implemented empirically using a

<sup>2</sup> No. 1 Documents are the top-priority documents issued jointly at the beginning of each year by the Central Committee of the Communist Party and the State Council. They are the first major policy directives of the year and give policy suggestions for the National People's Congress (OECD, 2009).

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