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Agricultural reforms and production in China: Changes in provincial production function and productivity in 1978–2015

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ABSTRACT

A series of fundamental and market-oriented reforms since 1978 have dramatically reshaped China's agricultural sector, which had been sluggish during the socialist period. Besides productivity growth and efficiency changes, the shape of the production function may also transform rapidly over time. Moreover, the four segments in agriculture (farming, forestry, animal husbandry, and fisheries) have different production processes and techniques, so the aggregated production function of agriculture may vary across provinces. Compared with existing studies, which usually assume a fixed production function, this paper allows a varying coefficient production function that can better capture the structure change in the six reform periods over the past four decades. The empirical results show that the labor elasticity is decreasing, the fertilizer and machinery elasticities are increasing, and the land elasticity has a U-shaped curve across time. Moreover, technology and inputs are leading the growth alternatively in different reform periods.

1. Introduction

Remarkable agricultural growth has been witnessed in China due to the rural reforms implemented since 1978. The real growth rate in the Gross Value of Agricultural Output (GVAO) is 6.1% per year over the period of 1978–2015, compared with an average 2.5% increase in the socialist period (1949–1977). Several waves of institutional reforms and market deregulations in the supply side not only helped achieve tremendous improvement in productivity, but also overwhelmingly reshaped the agricultural process and production function of agriculture.

Farming, forestry, animal husbandry, and fisheries are the four segments in China's agricultural sector, each with its own production process. Therefore, the aggregated production function of agriculture also depends on the share by segment in each province. Chinese economic reform has improved living standards and food consumption. The demand for animal protein has increased rapidly and therefore raised the ratio of animal husbandry and fisheries in the agricultural sector, which also altered the shape of the agricultural production function.

To summarize, the fundamental reforms that have been implemented since 1978 have reshaped agricultural production from both the demand side and the supply side. The first puzzle is that the traditional method with a fixed production function assumption fails to capture the changing input-output relation across time due to rural reforms in China. To solve this issue, this paper employs a varying production function to better control the impact of remarkable agricultural evolution, which is not only important, but also necessary.

Another puzzle is the debate about China's agricultural productivity growth since the late 1990s. Some scholars (Dekle and Vandenbroucke, 2010; Pratt et al., 2008; Wang et al., 2013) assert that the productivity growth rate peaked in the late 1990s and then gradually lost its momentum. Other researchers (Chen et al., 2008; Chen, 2006a; Tong et al., 2009; Zhou and Zhang, 2013) point out that the significant slowdown had already happened in the late 1990s and subsequently rebounded.

This article analyzes China's rural reforms and agricultural revolution using a two-step approach. In the spirit of the varying coefficient model and stochastic frontier analysis, this article first develops a semi-parametric approach to estimate the time- and province-variant production function, as well as total factor productivity (TFP). In the second step, we analyze the changes in input elasticities and productivity in six reform periods to determine the impacts of different rural policies on China's agricultural sector.

This study makes three central contributions. Firstly, a semi-varying coefficient method is introduced to better capture the fundamental transition in China's agricultural sector. Secondly, this study not only estimates the productivity and efficiency changes, as in classic productivity analysis, but also the changes in input elasticities across provinces

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and time. Thirdly, this article further links the six rural reforms in China with agricultural production and contributes to the debate about China's agricultural productivity growth in the past 20 years.

The empirical results show that in 1978–2015: 1) the production function is indeed province- and time-variant, which reflects the fundamental transition of China's agriculture; 2) the labor elasticity is decreasing, the fertilizer and machinery elasticities are increasing, and the land elasticity has a U-shaped curve across time; and 3) China's agricultural productivity growth has obvious cyclical fluctuations and six cycles are witnessed. Moreover, the direction of changes in output and productivity has always been opposite in the past two decades, which indicates that technology and inputs are leading the growth alternatively in different reform periods. Finally, the input growth contributes more to the output in the current phase, which implies an extensive pattern of economic growth and that more technology innovation is needed to improve productivity.

The remainder of the article is structured as follows. Section 2 reviews China's six rural reform periods since 1978. Section 3 introduces the existing agricultural productivity analysis in China. Section 4 builds the theoretical model and Section 5 describes the data. Empirical results are presented and analyzed in Section 6. Section 7 concludes the article.

2. Agricultural policy reforms in China

Brümmer et al. (2006) divide China's rural reform from the late 1970s to the early 2000 into five phases: 1978–84, 1985–89, 1990–93, 1994–97, and post-1998. Zhang and Brümmer (2011) further add a sixth period that starts at 2004. This article follows this period division.

The first period (1978–84) is the transition from the collective system to a household-based farming system (Lin, 1992). The main content is the implementation of the household responsibility system (HRS), which endows farmers with the right to control their own production after fulfilling government procurement quotas. By the end of 1983, 98% of the production teams in China had adopted HRS (Lin, 1995). Decollectivization and decentralization in this phase diversified the rural economy and turned to economic incentives to spur growth (Oi, 1999). Many studies confirmed the essential success and achievements in this period.

The second period (1985–89) witnessed a two-tier system, including both market and planning factors. The government further liberalized agricultural pricing and marketing systems by allowing more products to trade in the market (Yao, 1994), except for some strategic products, such as grain and cotton (Zhang and Brümmer, 2011). The removal of legal restrictions on exchanges of inputs (on a limited basis) reduced resource misallocation (Lin, 1995). However, agricultural output growth slowed due to the rising production costs (Fan et al., 2002a) and the frequent adjustments of policies in favor of the market economy or planned economy (Brümmer et al., 2006). In contrast to the first phase, this regime received some criticism.

The third period (1990–93) further reformed the united procurement and marketing system. In order to avoid government failure due to information problems, China substituted a centrally planned system and governmental interference by functioning market forces and solutions. By the end of 1993, over 90% of all agricultural products were sold at market-determined prices (Fan et al., 2002a). However, the market reform was not fully complete because of the segmentation of regional markets and the isolation of domestic markets (Brümmer et al., 2006). Moreover, the acceleration of rural industry absorbed agricultural resources, such as labor, land and capital.

The fourth period (1994–98) began with tax system reform, which increased state funds for agriculture and the capability of "industry nurturing agriculture." The government was able to raise procurement prices for grain by 40% in 1994 and by another 42% in 1996, which narrowed the procurement/market price gap and stimulated agricultural production. The extension of land contracts and the awareness of farmers' use rights encouraged more investment in land (Lambert and Parker, 1998). Moreover, the self-sufficiency policies at the regional level forced relatively developed regions to produce enough food to feed themselves.

The fifth period (1998–2003) can be regarded as an integration of rural development with the overall economic reforms (Zhang and Brümmer, 2011). The government implemented a new series of procurement and marketing reforms in 1998, aiming to relieve the financial burden of the grain support program. However, the dilemma of the State-owned grain enterprises caused many problems. China's World Trade Organization (WTO) accession in 2001 brought a reduction in protection policies and the quota procurement system was finally eliminated in the same year. At the end of this period, the free grain market was brought to most regions of China.

The sixth period (2004-present) was focused on the so-called "three nongs" (agriculture, farmers, and the countryside) issues. The trade status of agricultural commodities in China switched from a surplus to a deficit in 2004 (Chen et al., 2008), which called attention to food security. Since that same year, the government has highlighted the rural reforms in its first annual document, aiming to raise agricultural production capacities and increase farmers' income (Wang et al., 2013). In 2004, China began a nationwide push to abolish agricultural taxes; they were totally eliminated in 2006 (Lohmar et al., 2009). In 2005, a central land policy was stipulated to preserve at least 1.8 billion mu (120.6 million hectares) of arable land (Chien, 2015). The rural reforms in recent years are in a more comprehensive and sophisticated framework.

3. Agricultural productivity analysis in China

Thanks to the fundamental reforms and rapid growth, more and more scholars are paying attention to the productivity analysis in China's agriculture sector (e.g. Huang and Rozelle (1996); Cao and Birchenall (2013)). Lin (1992) discusses the price reforms, the institutional reforms, and the market and planning reforms during the first two regimes. He employs both a traditional production function and a stochastic frontier function to evaluate the contributions of rural policies to China's agricultural productivity growth. Using the province-level panel data from 1970 to 1987, he finds that 40% of the output growth was attributable to the introduction of the HRS during the first reform phase. The important impact of HRS and the rapid growth in productivity in 1978–84 are supported by many other studies (e.g., Mcmillan et al. (1989); Wen (1993); Fan et al. (2002b, 2004)).

Most of these studies also agree on the significant slowdown in agricultural growth in the second period. For example, Carter and Estrin (2001) claim that the productivity growth rate was 8.1% in the first phase, and declined to 2.4% in the second phase. Some (Fan, 1991; Fan et al., 2004; Lin, 1992; Mcmillan et al., 1989) believe that the decollectivization of farms in the first period could only provide a one-time productivity gain, which inevitably vanished in the second period. Others (Huang, 1998; Sicular, 1995) attribute the decline to the government's failure in market liberalization after 1984.

A new wave of literature studies China's agricultural productivity growth in the 1990s and the 2000s. Although most of these researchers find that the productivity growth rebounded in the early 1990s, as compared with the second period, the changes since the late 1990s are controversial. Some scholars (Dekle and Vandenbroucke, 2010; Pratt et al., 2008; Wang et al., 2013) assert the productivity growth rate peaked in the late 1990s and then gradually lost its momentum. Other researchers (Chen et al., 2008; Chen, 2006b; Tong et al., 2009; Zhou and Zhang, 2013) argue that the significant slowdown actually happened in late 1990s and rebounded afterwards. In terms of the last regime, from 2004 to the present, Wang et al. (2013) find that the growth rate further declined, while Zhou and Zhang (2013) argue that the growth rate has rebounded once again.

In terms of the estimation methods, Wu (2011) surveys 74 studies published from the 1990s onwards that focus on estimating total factor productivity in China. He finds that conventional production function is