Efficiency and Technological Progress in the Chinese Agriculture: the Role of Foreign Direct Investment

By

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Short summary

This study analyzes the role of foreign direct investment in contributing to regional differences in productive efficiency in Chinese agriculture. We use a stochastic frontier production function model, explicitly incorporating foreign capital, to investigate the relative performance of the aggregate agricultural sector across provinces and over time. Thus we can determine if foreign direct investment policies might reasonably be expected to change the competitive environment of regional agricultural sector. We calculate an index of productive efficiency and estimate the determinants of regional variations in it.

Key Words: Chinese agriculture, technical efficiency.

JEL Classification: F140.

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Economic growth in Chinese agriculture in the last decade has been steady. The annual growth rate of GDP in agriculture was 4 percent during the period 1984-1995 and 3.4 percent during the period 1996-2000, according to Huang and Rozelle, 2001. Although agricultural growth decelerated after 1985, it still outpaces the rise in population (Table 1).

From the total factor productivity (TFP) theory, technological progress, input accumulation, and technical efficiency contribute to the productivity change together. With the steady increase of FDI in the Chinese agricultural sector, the effect of FDI on the productivity change, particularly on technical efficiency and technological progress, remains an unsolved issue. How FDI affects the pace and pattern of technological progress and technical efficiency has not been discussed explicitly. This study investigates the role of FDI on TFP growth via technical efficiency and technological progress in Chinese agricultural sector.

The overall goal of our paper is to understand how FDI will affect the agriculture sector in China. The paper is organized as follows. The first section provides an overview of the agricultural sector in China and FDI in agriculture. Section 2 presents the framework of our model and related issues. Section 3 describes the data and its application. Section 4 discusses the empirical findings and some policy implication.

1. FDI in the Chinese agricultural sector

Since 1978 when economic reform and opening-up policy was initiated in the countryside, Chinese government calls for more foreign capital in agriculture and has tries to open various channels to attract foreign capital. The amount of foreign capital inflow has kept growing. Until 1992 loans were the most important element of these flows in Chinese agriculture. Foreign loans are largely sourced from bilateral (50 percent) and multilateral (30 percent) agencies, with only 20 percent coming from commercial sources. The world bank, with $5.6 billion, was the largest provider of these loans. However, in 1992, FDI exceeded loans.

FDI in Chinese agriculture has experienced three periods: In the first period, from 1980 to 1988, the amount of foreign capital is very less and the agreed amount only reaches 1 billion dollars. In the second period from 1989, the amount of foreign capital has greatly increased. During the 1990s, FDI increased in an average rate of 66.1 percent, comprising three-fourths of the actual capital inflow. From 2002 till now is a new development period for FDI in agriculture.

China has been an important regional host for FDI in agriculture with long-standing policies designed to encourage sustainable development with increased productivity. The objective of the FDI inflow to Chinese agriculture is to make up the shortage in domestic investment, to accelerate the introduction of advanced technologies and to promote the process of industrialized farming operations. However, foreign direct investment in Chinese agriculture has been very small, and is dwarfed by foreign investment in other segments of the Chinese economy.

2. Theoretical framework and model

This study employs a stochastic frontier production function approach. This approach defines the production frontier corresponding to the set of maximum attainable output levels for given combinations of inputs. The stochastic frontier production function was first proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The original specification involved a production function specified for cross-sectional data which had an error term which had two components, one to account for random effects and another to account for technical inefficiency.

The stochastic frontier production theory postulates the existence of technical inefficiencies of production. Technical efficiency of a firm is defined by Farrell (1957) as the ability of a firm to produce maximum output from a given set of inputs. When a firm is technically efficient, the maximum output is generated from a combination of inputs. Many previous frontier production functions have not explicitly formulated a model incorporating the technical inefficiency effects. Estimation of the technical efficiency measure enables us to uncover systematic influences that cause the unexplained variation in output, and to quantify the effects of factors that are believed to affect technical efficiency.

Thus their model specification can be expressed as:

$$Y_{it} = X_{it}\beta + V_{it} - U_{it}$$

where Y_{it} is the production of the i-th region, X_{it} is a kx1 vector of input quantities of the i-th region, β is the vector of unknown parameters, V_{it} is a symmetric error component that captures statistical noise, is assumed to be independent and identically distributed as normal random variables with zero mean and variance σ_v^2, i.e. $N(0, \sigma_v^2)$ and independently distributed of the U_{it} , and U_{it} is non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the normal distribution with mean m_{it} and variance σ_v^2, where

$$U_{it} = Z_{it}\delta + W_{it}$$

where Z_{it} is a px1 vector of variables which may influence the efficiency of a region, and δ is an 1xp vector of parameters to be estimated. W_{it} is defined by the truncation of the normal distribution with zero mean and variance σ_w^2.

Accordingly, the technical efficiency of production for the i-th region is defined by

$$TE_{it} = \exp(-U_{it}) = \exp(-Z_{it}\delta - W_{it})$$

Pitt and Lee (1981) adopted a two-stage approach to deal with the explanation of these inefficiency effects: in the first stage, the specification and estimation of the stochastic frontier production function and the prediction of the technical inefficiency effects are done, under the assumption that these inefficiency effects are identically distributed. The second stage involves the specification of a regression model for the predicted technical inefficiency effects in terms of various explanatory variables and an additive random error. However, the estimation of the second-stage inefficiency model contradicts the assumption of identically distributed inefficiency effects in the stochastic frontier.

The issue was addressed by Kumbhakar, Ghosh and McGukin (1991) who propose stochastic frontier models in which the inefficiency effects are expressed as an explicit function of a vector of firm specific variables and a random error. Battese and Coelli (1995) propose a model equivalent to the specification by Kumlhakar etc., with the exceptions that allocation efficiency is imposed, the first-order profit maximizing conditions removed, and panel data is permitted.

The information used in investigation of the determinants of technical efficiency includes time and FDI. In our study, the hypothesized efficiency determinant is FDI. Using the specified stochastic frontier model we can measure technical efficiency of Chinese agriculture for the period of 1989-1993.

3. The data and Empirical Application

The database used in this study is from different issues of China Statistical Yearbook, Rural Statistical Yearbook of China and China Foreign Economic Statistical Yearbook. Following the above modeling specification, the empirical model for Chinese agriculture can be estimated as

$$\ln(Output) = \beta_0 + \beta_1 \ln(Labor) + \beta_2 \ln(Power) + \beta_3 \ln(Fertilizer) + \beta_4 \ln(Land) + V_{it} - U_{it}$$

where i indicates the *i*th province and t the *t*th year. The variables are as follows:

Labor. It was calculated in terms of the total actual employment of the agricultural sector in 10,000 persons.

Output. If refers to the total added value of products of farming, forestry, animal husbandry and fishery in million yuan. It is used as the dependent variable for production function of the agricultural sector.

Land. It is measured as the acreage of cultivated land in 1000 hectares.

Power. This refers to total mechanical power of machinery (in millions of horsepower) used in farming, forestry, animal husbandry, and fishery, including ploughing, irrigation and drainage, harvesting, transport, plant protection, stock breeding, forestry and fishery. It is used as the value of capital in the agricultural sector. Other factors such as draft animals are ignored here due to the limits of provincial statistics.

Fertilizer. It refers to the quantity of chemical fertilizers applied in agriculture in the year (in 10,000 tons), including nitrogenous fertilizer, phosphate fertilizer, potash fertilizer, and compound fertilizer.

All the data are at the provincial level. Using the above stochastic frontier model and the data for the years from 1989 to 1993, we can apply the maximum likelihood estimate and measure technical efficiency and total factor productivity for the Chinese agricultural sector.

4. Estimation Results

The maximum-likelihood estimates of the parameters of the stochastic frontier production model are obtained using the computer program, FRONTIER Version 4.1. The results of the estimation are demonstrated in Table 2.

Based on the estimates listed in the above tables, the following points can be made: First, labor negatively related to output. This indicates that an increase in employee number tends to affect agriculture output adversely. A reduction in use of labor can improve productive efficiency and increase output. The labor input was still overused in Chinese agricultural sector. Second, land also negatively related to output. From the raw data, the acreage of cultivated land in China was decreasing. For the determinants of technical efficiency, the coefficient FDI (δ_1) is positive, implying that an increase of FDI in agriculture contributes to technical efficiency. In addition, the time (t) is positively related to technical efficiency, indicating an increase of technical efficiency in the period of 1989-1993.

Thirty administrative units, the provinces, of China can be divided geographically into three big regions: coastal, central and western regions. The coastal regions include Beijing, Tainjin, Hebei, Laioning, Shanghai, Shandong, Zhejian, Jiangsu, Fujian, Guangdong, and Guangxi. The Central regions include Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Human, and Hubei. The western regions include Sichuan, Yunnan, Guizhou, Shaanxi, Gansu, Qinghai, Ningxia, Xizang and Xinjiang.

From Table 3, we see the acceleration of FDI inflow in agriculture in coastal regions which have markedly outstripped central and western areas in attracting AGFDI. The evolution of average technical efficiency levels for each region are listed in Table 4. We can see that there are significant differences between the three big regions. Production in coastal provinces is closer to the frontier than central provinces, which is also closer than western provinces. The western regions show significantly lower technical efficiency. For the regional differences, we have seen that Guangdong ranked the top in attracting foreign direct investment among all provinces and municipalities.

5. Policy Implication

The past policy environment has not provided equal opportunity for all to invest in agriculture. The early restrictions on FDI location and subsequent liberalization, made policy the primary determinant of investment location. The official policy concentrated investments along the Coast in the 1980s and the investment accumulation continued to attract FDI in the 1990s. As late as 1996, about 85 percent of FDI inflows to agriculture were into the Eastern region (the coastal provinces plus Beijing and Hebei). There are obvious regional differences in attracting FDI. Regional disparities also warrant further studies on other socio-economics characteristics of agricultural production. As Chinese government strongly encourages the economics development of the Southwest through its Great Western Development Initiative, further research should be done on the socio-economics reasons for the regional differences and therefore the central government can take relevant steps to woo FDI in agricultural sector and maintain sustained and fast growth.

Table 1. The annual growth rates (%) of China's economy, 1970-2000.

	Pre-reform	Reform period		
	1970-78	1979-84	1985-95	1996-2000
GDP	4.9	8.5	9.7	8.2
Agriculture	2.7	7.1	4.0	3.4
Population	1.8	1.4	1.37	0.9

Table 2. Maximum-Likelihood Estimates of the Stochastic Frontier Model for Chinese Agriculture production

Coefficient	Estimate	Standard Error	t-ratio
β_0	103.055	2.178	47.316
β_1	-0.111	0.0153	-7.246
β_2	0.067	0.024	2.842
β_3	3.221	0.304	10.597
β_4	-0.018	0.005	-3.553
δ_0	0.001	0.100	0.001
δ_1	0.010	0.002	5.245
t	0.011	0.008	1.351

Table 3. Amount of Capital (USD 10,000) –Agreement of FDI in Agriculture in Different Regions

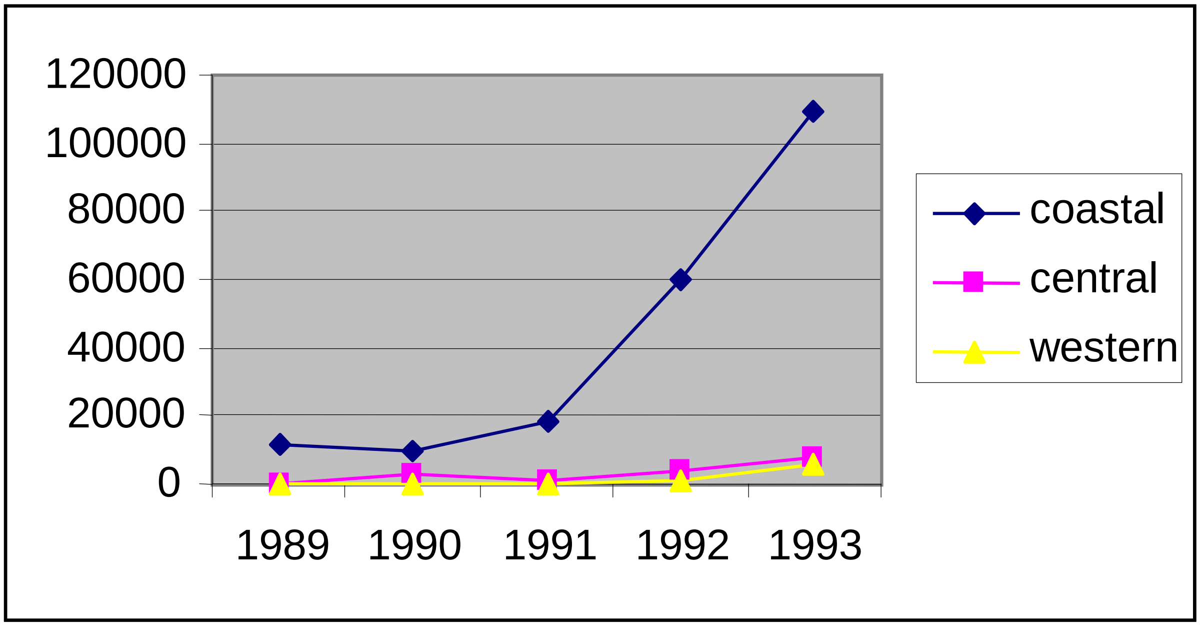

Table 4. Technical Efficiency Estimates by Region for Agriculture Production

	Coastal provinces	Central provinces	Western provinces
1989	0.8602	0.8482	0.7111
1990	0.8856	0.8564	0.7369
1991	0.8867	0.8675	0.7624
1992	0.8997	0.8805	0.7726
1993	0.9185	0.8917	0.8034

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