



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

New Challenges Facing Asian Agriculture under Globalisation

Volume II



Edited by

Jamalludin Sulaiman
Fatimah Mohamed Arshad
Mad Nasir Shamsudin

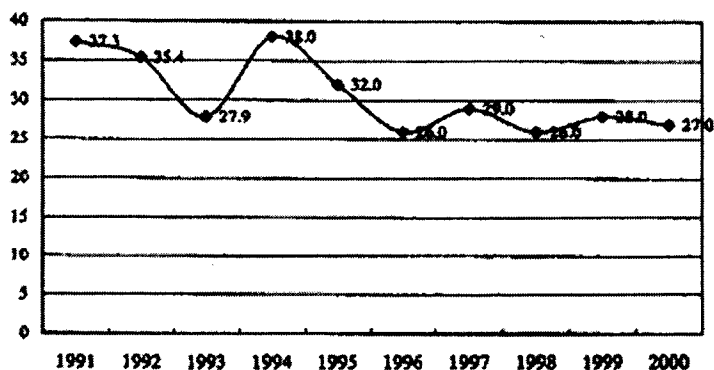
Technical Efficiency and Water Management in Central Asia: Case of Private Farms in Uzbekistan

Masahiko Gemma

Introduction

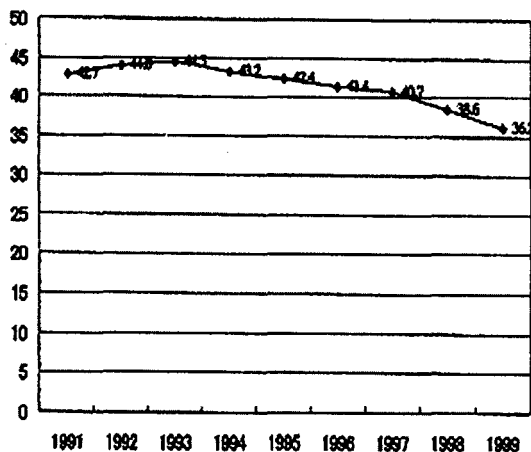
Uzbekistan has been going through a transition process for the past 10 years. Many old collective and state owned production units have been privatized. The emergence of new businesses in manufacturing and retail service sectors of small and medium size has been observed. Liberalization of markets has also started, but the progress has been slow in Uzbekistan.

Agriculture in Uzbekistan still plays a significant role in the national economy. This sector occupies about 27.0 per cent of the Gross Domestic Product (GDP) in production (Figure 48.1). It also provides working opportunities for 36.2 per cent of the total labour force (Figure 48.2). The slow pace of the changes in these figures indicates the slow progress in reforming the structure of the economy in Uzbekistan. Agricultural products are the major sources of foreign currency earnings for this economy. Cotton has been historically produced, taking advantage of the natural conditions suitable for this crop's cultivation with the existence of extensive rural infrastructure in water resource management that was developed during the period of the Soviet Union. Cotton has remained important as a strategic crop for hard currency earning. This crop earns about one third of the foreign currency revenue through exports.



Source: Interstate Statistical Committee of the Commonwealth of Independent State (2000)

Figure 48.1: GDP Share of Agriculture in Uzbekistan



Source: Interstate Statistical Committee of the Commonwealth of Independent State (2000)

Figure 48.2: Labour Share of Agriculture in Uzbekistan

Private ownership of agricultural land has not been allowed even after the country's independence in 1991 from the Soviet Union. The government has been offering long-term leasing contracts to the private farmers for their use of agricultural land. Typical lengths of the leasing contracts range between 10 years to 20 years. The share of the private farms in agricultural production stays small, but this sector should play a major role in agricultural production as progress is made in liberalizing the agricultural and related markets in the future. This current study looks into issues related to technical efficiency and water resource management for this important sector in Uzbekistan agriculture. For this sector's survival in the market economy, the improvement in technical efficiency is critical. In this study, using a set of surveyed data for private farms from the Djizak region of Uzbekistan, technical efficiency in the individual farm level is estimated and the factors accounting for the difference in technical efficiency are identified to derive policy implications. Water resource management issues will be considered.

The structure of the paper is as follows. The current status of Uzbekistan agriculture is described first. The methodology and data utilized in this study is explained next. The results of data analysis are presented in the following section. Then, discussions are made to derive policy implications in the last section.

Agriculture in Uzbekistan

A major policy change introduced after independence for Uzbekistan agriculture is the adoption of self-sufficiency policy in food. Cotton was widely produced and shipped out from the Republic of Uzbekistan under the central planning system in the Soviet Union. Wheat was then produced domestically in the Republic, but was partly imported from other Republics for domestic consumption. The import substitution policy to grow wheat in Uzbekistan started right after 1991. With the introduction of the state order system to impose

production quota for growing wheat, wheat production has increased. The land allocated for cotton production has declined as a result of the increasing use of arable land for wheat production. Since the government procurement prices for wheat as well as cotton have been maintained much lower than the international prices, the possibility for improvement in profitability in agricultural production has been limited.

Large-scaled collective farms have been converted to new forms of enterprises in Uzbekistan agriculture. However, these farms still maintain large-scaled operation and dominate local labour and agricultural output markets. For inputs like chemical fertilizer, seeds, machinery services and water supply, local production cooperatives, which have been converted from former Kolkhozes, also rule their distribution. Private vendors in local markets can provide some amount of these inputs, but the quantities are limited.

A new development that we have observed for the past 10 years in Uzbekistan agriculture is the emergence of the private farms. Some managers and workers of former state farms started their own agricultural operation, using the land that has been leased out from the government and equipment and machinery that have been purchased for bargain prices from liquidated former collective farms. Some private farms operate in a large scale, with a total land use of more than 100 hectares. Although this group of farms still occupies a small portion of national agricultural production, a major role should be played in the future as more liberalization measures are implemented in Uzbekistan agriculture.

Methodology and Data

Crop yields vary among different farms in Uzbekistan. The accessibility to water creates a large difference among them. Irrigated farms produce yields between 1.5 tons per hectare to 4.5 tons per hectare. These yield numbers are lower than the average yields in major cotton producing countries such as China and the US. It will be beneficial to identify the factors that influence this difference in production among irrigated cotton farms for Uzbekistan agriculture using sample data from the field. This exercise would create useful policy implications related with water resource management for the future improvement in technical efficiency of the production of this strategically important crop.

Since Farrell's (1957) seminal paper and the subsequent papers published on the efficiency and productivity measurement, production frontier techniques have been widely applied to address the issues relating to production efficiencies in crop production.

The deterministic and probabilistic production functions usually model the production process, assuming a one sided error term of the form

$$Y = f(X_1, X_2, \dots, X_n) \pm e \quad (1)$$

where the error term e acts as a downward shifter of individual production units given an efficient frontier $Y = f(X_1, X_2, \dots, X_n) \pm e$ in the case of production ($-e$) or upward shifter in the case of a cost function ($+e$). In this approach, all firms are assumed to share a common family of production, cost and profit frontiers and all variation in firm performance is

attributed to the common family of frontiers. However, aggregating the effects of exogenous shocks with the effects of measurement and inefficiency into a single one-sided error term is a questionable assumption. To overcome this difficulty, composed error models have been proposed, which are otherwise known as stochastic frontier models. The main advantage of stochastic frontier approach is its ability to decompose the deviation from the frontier into stochastic noise and technical inefficiency components.

Following Aigner *et al.* (1977), the production function can be specified by the 'Stochastic Frontier'

$$\ln Y_i = \ln f(X_i; \beta) + \varepsilon_i \quad i = 1, 2, \dots, N \quad (2)$$

where Y_i = output for observation i , X_i = vector of inputs for observation i , β = vector of parameters and ε_i is an error term. The frontier model is also called a 'composed error' model because the error term ε_i is assumed to be the difference of two independent random variables,

$$\varepsilon_i = v_i - u_i, \quad i = 1, 2, \dots, N \quad (3)$$

It is assumed that v_i is a two sided error term representing statistical noise such as the weather which is beyond the control of the researcher and $u_i \geq 0$ is the difference between the maximum possible stochastic output $f(X_i; \beta) + V_i$ and the actual output Y_i . So u_i represents technical inefficiency. When the error component $U_i = 0$, the output of the observation lies on the frontier and so it is 100% efficient.

In most of the empirical studies, it is assumed that the stochastic variable v_i is normally distributed with mean 0 and variance σ_v^2 , that is $v_i \sim N(0, \sigma_v^2)$ and u_i is half normal, that is, $u_i \geq 0$ and $u_i \sim N(0, \sigma_u^2)$. With this assumption, Jondrow *et al.* (1982) have shown that the conditional mean of U_i given ε_i is equal to

$$E(u_i | \varepsilon_i) = \left(\frac{\sigma_u \sigma_v}{\sigma} \right) \left[\frac{\phi(\varepsilon_i \lambda / \sigma)}{(1 - \Phi(\varepsilon_i \lambda / \sigma))} \right] - (\varepsilon_i \lambda / \sigma) \quad (4)$$

where,

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda = \frac{\sigma_u}{\sigma_v}$, $\phi(\cdot)$ and $\Phi(\cdot)$ are respectively density and cumulative density functions of standard normal variate. The variance ratio parameter

$$(\tilde{\alpha}) = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2) \quad (5)$$

A measure of technical efficiency of observation i is given by

$$TE = e^{-E(u_i/\varepsilon_i)} \quad (6)$$

and the population mean level of technical efficiency, as given by Pitt and Lee (1981) is

$$E(e^{-u}) = 2e^{\sigma^2} [1 - \Phi(\sigma)] \quad (7)$$

When the production function is specified by a Cobb-Douglas function, (2) takes a simple form,

$$Y_i = X_i\beta + v_i - \mu_i \quad (8)$$

where Y_i = logarithm of output Y_i and X_i is a column vector of logarithms of inputs.

To estimate the parameters, it is assumed that we have a random sample of N observations and then forming the log-likelihood function

$$\ln L = \left(\frac{N}{2} \right) \ln \left(\frac{2}{\pi} \right) - N \ln(\sigma) + \sum_{i=1}^N \ln \left[1 - \Phi \left(\frac{\varepsilon_i \lambda}{\sigma} \right) - 1 \left(\frac{1}{2\sigma^2} \right) \sum_{i=1}^N \varepsilon_i^2 \right] \quad (9)$$

Estimation of the parameters is done by maximizing (8). The method usually followed in the literature is the Davidon-Fletcher-Powell algorithm. This study employs this algorithm.

For the estimation of technical efficiency, a Cobb-Douglas specification of the following form is utilized.

$$\ln Y_i = \hat{\alpha}_0 + \sum_{j=1}^n \hat{\alpha}_j \ln X_j + V_i - u_i \quad (i=1 \text{ to } n) \quad (10)$$

where, Y_i = wheat production in tons per hectare; X_i are inputs such as seeds (kgs per hectare); fertilizer (soums per hectare); machinery (hours per hectare); irrigation (water supplied by cubic meter per hectare). As more appropriate figures to represent the amount of the labour used on farm could not be obtained, the aggregated number of family labour and hired workers is used as an input variable to account for the difference in labour use among the sample farms. $\hat{\alpha}_0$ and $\hat{\alpha}_j$ are parameters to be estimated and v and u are random and one sided error terms.

The technical efficiency relative to stochastic production function is calculated as:

$$u_i = \log y - (\hat{\beta}_0 + \hat{\beta} \sum \log X_i + V_i) \quad (11)$$

The farm specific technical efficiency is calculated using the expression:

$$TE_i = e^{-u_i} \quad (12)$$

Since individual private farms are different in terms of the location in irrigation systems, the quality of soil, the size of operation and educational backgrounds and past experience in agricultural operation, production of the farms will be subject to different levels of technical efficiency. It is therefore equally important to identify the factors contributing for their inefficiencies. The outputs from such an examination would help the government as well as farm managers to take appropriate measures for the improvement of technical efficiency.

For the estimation, the linear function is used to explain the relationship between the farm specific technical efficiency and the independent variables that show the characteristics of individual farms:

$$TE_i = a_0 + \sum_{i=1}^n a_i s_j + w_j \quad (13)$$

where TE_i = estimated technical efficiency, S_j = socio-economics, institutional and biological factors, a_i = parameters to be estimated, W_j = disturbance term with normal properties.

Data collection was carried out during the off-season in 2000 in the Djzak region located in the southwest of Tashkent about 150 km. The data are from the crop year of 1999. Because of its importance for the national economy and water management, cotton produced in irrigated areas is the main focus of this study. The data from the surveyed farms of 405 are utilized for this econometric analysis. Limdep program is employed for the estimation of the frontier production function, calculation of technical efficiency and factor analysis.

Results of Data Analysis

Table 48.1 summarizes the estimation results of the stochastic frontier production function in the Cobb-Douglas specification for the sample cotton producing farms in Uzbekistan. All the statistically significant coefficients show theoretically correct signs.

The marginal contribution of land to production is large. The same figure for labour is small as compared to typical figures from other studies, and does not represent the local condition of relatively intensive use of labour. As the labour variable utilized for this study includes only the contribution by hired labour, and does not represent the role of family labour here, the ability of our labour variable to explain the variability of cotton production is limited. The coefficient on the fertilizer variable is statistically significant. This indicates that fertilizer supply in Uzbekistan agriculture is critical for the growth of cotton production.

Technical efficiency (TE) can be calculated using the relationship shown in equations 11 and 12. The distribution of TE among the sample farms is presented in Table 48.2. There exists a wide diversity in its distribution, but many are concentrated in the relatively high level of technical efficiency. The calculated individual TEs range between 17.93 and 97.77. The average level of TE for the whole sample farms is 76.02. More than two thirds of the farms fall in the efficiency category of more than 70 per cent. About 13 percent of the farms exhibit low technical efficiency level of less than 60 per cent.

Table 48.1: Results of the Stochastic Frontier Model for Cotton Production in Uzbekistan

Variables	Coefficients
Dependent Variable: ln(production)	
Constant	0.9613 (0.1934)***
Ln(land)	0.9551 (0.0510)***
Ln(Labour)	0.0233 (0.0064)***
Ln(Seed)	0.0051 (0.0337)
Ln(Fertiliser)	0.0044 (0.0025)*
Ln(Machinery)	0.00129 (0.0189)
Ln(Irrigation)	-0.000003 (0.0248)
Lambda (λ)	4.00095 (0.4163)***
Sigma	0.4127 (0.0131)***
Log likelihood function	-4.0046
σ_v^2	0.0010
σ_u^2	0.1603
Number of observations	404

Notes: The numbers in the parentheses are standard error.
*10 per cent significance level and *** 1 per cent significant level.

Table 48.2: Grouping of the Sample Private Farms by Technical Efficiency (TE)

Grouping of TE (%)	Number (%)
<20	1 (0.2)
20-30	4 (1.0)
30-40	14 (3.5)
40-50	10 (2.5)
50-60	24 (5.9)
60-70	55 (13.6)
70-80	86 (21.3)
80-90	153 (37.8)
90 <	58 (14.3)
Total	405
Sample mean	76.02

Farm specific factors can be examined to identify the reasons that create the difference in technical efficiency among the surveyed farms using equation 13. The findings are summarized in Table 48.3. The difference in natural conditions, such as the existence of salinity problems, is explained by the first variable. Salinity-Serious explains the share of the land under salinity problems, even at the stage of almost irreversible conditions. A negative sign of this variable implies that the larger the problem in salinity, the lower the technical efficiency. Solving and avoiding salinity problems must be essential for improving technical efficiency in cotton production in Uzbekistan.

Table 48.3: Factors Influencing the Technical Efficiency in Cotton Production in Uzbekistan

Dependent variable: Technical efficiency
Ordinary least square estimation

Variables	Coefficients	Coefficients
Constant	77.4890 (1.0729)***	77.3468 (1.0880)***
Salinity-serious	-0.1695 (0.0407)***	-0.1663 (0.0408)***
Tail of irrigation system	-2.4353 (1.4896)	-2.4462 (1.487)
Receiving advice on water use	2.7697 (1.4069)	
Receiving training on water use		3.0003 91.4191)**
Primary education	-2.0282 (1.2245)*	-2.0963 (1.2229)*
University education	2.9408 (1.2654)**	2.7859 (1.2790)**
Adjusted R ²	0.946	0.946
Number of observations	405	405

Notes: The numbers in the parentheses are standard errors.

*10 per cent significance level, ** 5 per cent significant level and *** 1 per cent significant level.

Locations of the farms in the irrigation systems make a difference in technical efficiency. The private farms that are located at the end of the irrigation systems show lower technical efficiency. The coefficient on this variable has a negative sign and is statistically significant at the level of 11 percent. The accessibility to water seems to be important in materializing higher technical efficiency.

The rest of the explanatory variables, listed in Table 48.3, are the variables related with the experience in training and advisory programs for water use and the educational background of the heads of the private farms. The farms that receive advice on water use from the water providers, mainly local agricultural cooperatives, are more technically efficient than the farms without receiving such services. The farms directed by the family heads, who have received training on water use, also perform better than others.

Primary Education and University Education are the variables to represent the educational background of the family heads. These are the dummy variables. If the final education that a family head received was elementary school education, 1 was put for the variable of Primary Education. The same rule was applied for University Education variable.

The private farms that are managed by only primary education show lower technical efficiency. On the other hand, the farms directed by university graduates demonstrate higher technical efficiency. Higher education programs appear to be contributing to betterment in the efficiency of cotton production in Uzbekistan.

Conclusions and Policy Implications

Some observations can be made through the data analysis presented in the above. Water resources were found to be important in cotton production for the private farms in Uzbekistan.

The status of salinity problems was a factor to explain the difference in technical efficiency among the survey farms. Because of dried and hot climatic conditions in Central Asia, surface water does not regularly reach ground water basins. Water in the soil evaporates up to the surface. In this process, salt and its compounds move up to the ground surface. Crops do not grow well in this type of saline soils. Land improvement efforts to cope with salinity problems will certainly give better performance in cotton production in Uzbekistan, we can argue.

The improvement in the accessibility to water resources should also significantly improve efficiency of cotton production in Uzbekistan. The Uzbek government and the international community could look into the possibility to rehabilitate and to further improve the water management facilities. The water policy can be also modified to allow more allocation of water to private farms, especially to the ones located at the end of irrigation systems. For these issues, economic studies need to be carried out to evaluate the benefit and cost aspects of the changes in the current strategies and policies for water and irrigation facility management.

The variables that are generally considered important for improving technical efficiency were statistically significant in the above analysis. The difference in educational background explains the difference in the level of profitability in newly started private farms in Hungarian agriculture (Gemma, 1999). This seems to be also the case for Uzbekistan agriculture. Knowledge acquired in higher education programs and in training programs for better use of water seems to help the private farmers to be technically efficient. The advisory service on water use from the irrigation controllers was also helpful. The government efforts to increase the number of private farmers who can get access to the information on water use, should continue in Uzbekistan. Once again, further studies need to be done to assess the benefit-cost relationship of various educational programs and advisory services before new programs are implemented.

References

- Aigner, D.J., C.A.K. Lovell and P. Schmidt (1977). Formulation and Estimation of Stochastic Frontier Production Function Models, *Journal of Econometrics* 6, 21-37.
- Farrel, M.J. (1957). The Measurement of Productive Efficiency, *Journal of the Royal Statistical Society, A* 120, 253-281.
- Gemma, M. (1999). Economic Analysis of Agriculture in Transition Economies: Case of Hungarian Private Farms, *Proceedings of the Annual Conference of the Agricultural Economic Society of Japan*, Agricultural Economic Society of Japan, 512 -514.
- Interstate Statistical Committee of the Commonwealth of Independent States (2001). 10 Years of the Commonwealth of the Independent States (1991-2000).
- Jondrow, J., C.A.K Lovell, I.S. Materov and P. Schmidt (1982). On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model, *Journal of Econometrics*, 19, 233 -238.
- Pitt, M.M. and L.F. Lee (1981). The Measurement of Sources of Technical Inefficiency in the Indonesian Weaving Industry, *Journal of Development Economics*, 9, 43-64.