WATER MANAGEMENT AND AGRICULTURAL DEVELOPMENT IN CENTRAL ASIA: Case of Uzbekistan

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Uzbekistan has been going through the 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 in the 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 percent of the Gross Domestic Product (GDP) in production (Figure 1). It also provides working opportunities for 36.2 percent of the total labor force (Figure 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.

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 still small, but this sector should play a major role in agricultural production as the progress is made in liberalizing the agricultural and related markets in the future. This current study looks into issues related with 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 there.
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 form 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 the 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 labor 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 venders 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 the large scale with the total land use of more than 100 hectares. Although this group of the 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 Farell'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 an one sided error term of the form

$$Y = f(X_1, X_2, \ldots X_n) \pm e \qquad (1)$$

where the error term e acts as a downward shifter of individual production units given an efficient frontier $Y = f(X_1, X_2, \ldots X_n)$ 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.

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

where Yi = output for observation i, Xi = 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,

$$\varepsilon_i = v_i - u_i \qquad ,i = 1,2,\ldots N \qquad (3)$$

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

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

where,

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

(5)

A measure of technical efficiency of observation i is given by

$$TE_i = e^{-E(u_i/\varepsilon_i)} \qquad (6)$$

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

$$E(e^{-u}) = 2e^{\frac{\sigma_u^2}{2}}\left[1 - \Phi(\sigma_u)\right] \qquad (7)$$

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

$$Y_i = X_i \beta + v_i - u_i \qquad (8)$$

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

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

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.

Since individual private farms are different in terms of educational backgrounds, past experience in agricultural operation and training they have obtained for water use, production of the farms might be subject to different levels of technical efficiency. It is therefore 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 of technical efficiency, a Cobb-Douglas specification of production function was utilized. The factors determining the difference in technical efficiency were also identified. The estimation method developed by Battese and Coelli (1995) was usilized with the application of FRONTIER 4.1 (Coelli, 1996). A two stage estimation was carried out in a systematic way using this econometric program.

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 current study. The data from the surveyed farms of 405 are utilized for this econometric analysis.

Results of Data Analysis

Table 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 labor is small as compared to typical figures from other studies and does not represent the local condition of relatively intensive use of labor. As the labor variable utilized for this study includes only the contribution by hired labor and does not represent the role of family labor here, the ability of our labor variable to explain the variability of cotton production is limited here. 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.

Farm specific factors can be examined to identify the reasons that create the difference in technical efficiency among the surveyed farms. The findings are summarized in Table 2. All coefficients show negative signs. Having college education dose not seem to help in achieving higher technical efficiency in Uzbekistan. Training for efficient water use and having an opportunity to get an advice on water use do not help the private farmers, either. Even having these backgrounds seem to negatively influence the levels of technical efficiency.

The farms that receive advice on water use from the water providers, mainly local agricultural cooperatives, are not technically efficient than the farms without receiving such services. The farms directed by the family heads who have received training on water use also did not perform better than others. .

Conclusions and Policy Implications

Some observations can be made through the data analysis presented in the above. Water resources are naturally important in cotton production for the private farms in a desert country of Uzbekistan. However, traditionally important factors in agricultural development such as training and education, even getting advice, do not seem to make a difference in attaining technical efficiency for cotton production in Uzbekistan. The private farmers in the surveyed area might have been placed in disadvantaged situations. The status of salinity problems might be so bad and any reasonably priced technology might not solve the problem they face easily. Because of dried and hot climatic conditions in Central Asia, surface water does not regularly reach ground water basins. Water in the soil evaporates 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. Huge investment on land improvement might be required for the private farmers to improve the farming conditions. The lack of capital and low economic incentive to improve the soil conditions also exist. Land improvement efforts by the public sector to cope with salinity problems will certainly give better performance in cotton production in Uzbekistan. On going state purchase programs for cotton and wheat that having been limiting the production options for private farms need to be also lifted in the future to develop the private farming sector.

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, more detailed economic studies need to be carried out to evaluate the benefit and cost aspects of the changes in the current strategies and policies related to water and irrigation facility management.

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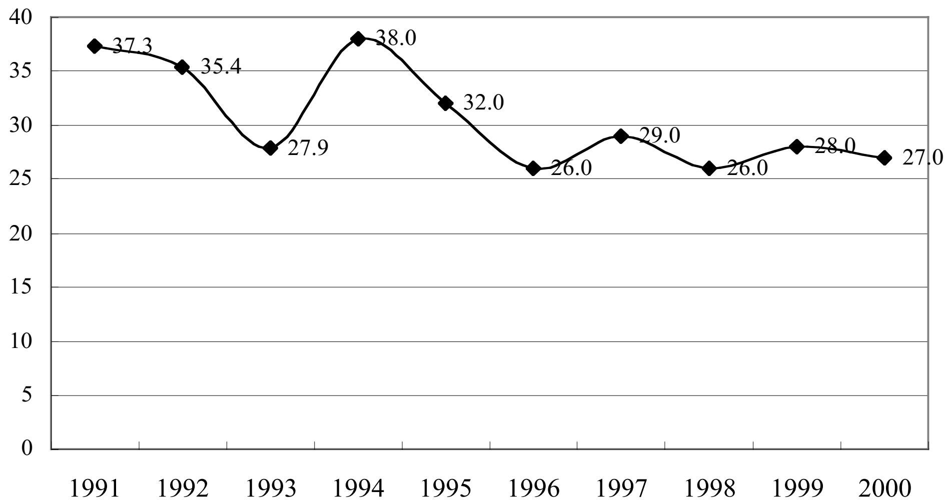
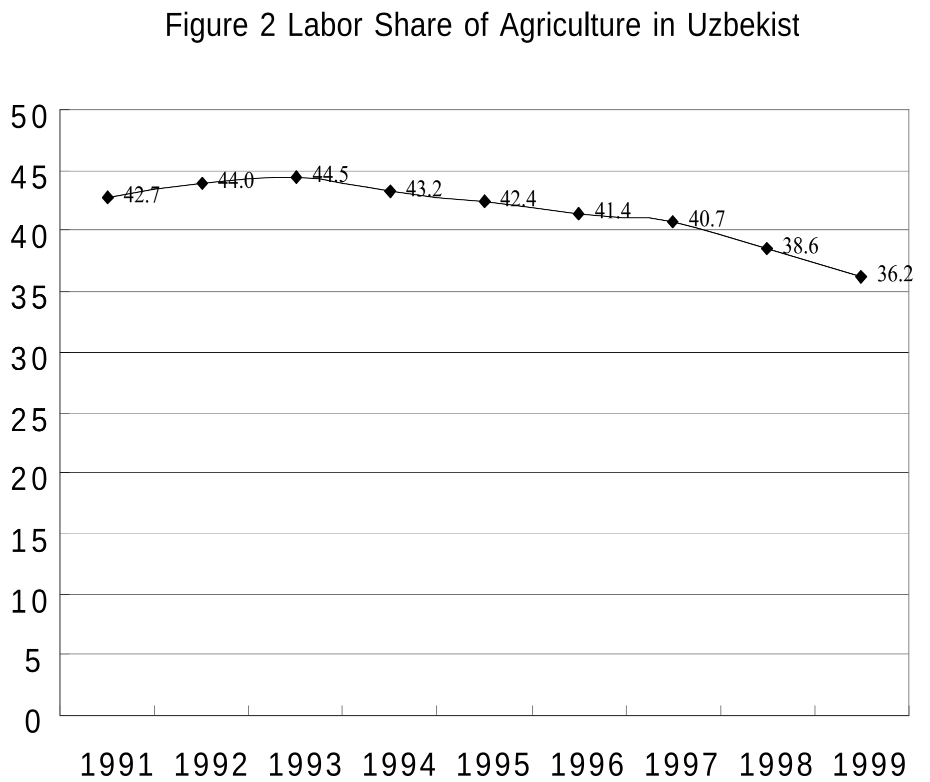
Figure 1 GDP Share of Agriculture in Uzbekistan (%)



Source: Interstate Statistical Committee of the Commonwealth of Independent States (2001



Source: Interstate Statistical Committee of the Commonwealth of Independent States (2001)

Table 1 Results of the stochastic frontier model for cotton production in Uzbekistan

Variables	Coefficients
Dependent variable: Ln(Production)	
Constant	.8657 (.0844)***
Ln(Land)	.9773 (.0221)***
Ln(Labor)	.0173 (.0061)***
Ln(Seed)	.0060 (.0131)
Ln(Fertilizer)	.0029 (.0022)*
Ln(Machinery)	.0157 (.0189)
Ln(Irrigation)	-.00002 (.0070)
Sigma-squared	1.938(.6509)***
Log likelihood function	-0.291418
Number of observations	405

The numbers in the parentheses are standard errors.
*10 percent significance level and ***1 percent significance level.

Table 2 Factors influencing the technical efficiency in cotton production in Uzbekistan

Variables	Coefficients
Dependent variable: Technical efficiency Ordinary least square estimation	
Constant	-5.0433 (2.0060)***
Receiving Advice on Water Use	-0.1950(0.1416)*
Receiving Training on Water Use	-2.4151(0.8503)***
University Education	-3.5646 (1.2179)**
Number of observations	405

The numbers in the parentheses are standard errors. *10 percent significance level, **5 percent significance level and ***1 percent significance level.