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The Impact of Agricultural Reforms on Tajikistan's Cotton Production Efficiency

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Abstract: This empirical study examines the impact of agricultural reforms on the cotton sector of Tajikistan. It investigates the level and determinants of technical efficiency for a sample of cotton growing regions in Tajikistan. Using unbalanced panel data of 11-years covering the transition period 1992-2002, 34 cotton-producing regions are analysed with a translog stochastic production frontier, including a model for regional-specific technical inefficiencies. The output elasticities, returns to scale, and indices of convergence are also examined. They reveal that the technical inefficiency effects are found to be highly significant in indicating the ranges and variation in regional outputs. The results show that reforms had a significant positive impact on technical efficiency of cotton production, which, in turn, has a substantial contribution to the process of economic development of Tajikistan.

Key words: agricultural reform, efficiency, cotton, Tajikistan

JEL Classification: O13, P21

Introduction

Following the fall of the Soviet Union in 1991, the Republic of Tajikistan became an independent state. From the beginning it was clear that the country had to change its centrally planned economic system and move to a new system by implementing a socio-economic reform process that could best achieve the processes of economic development and poverty alleviation. However, as a result of the breakdown of existing interstate relations within the former USSR, Tajikistan faced a long period of macro-economic and socio-political crisis, which deteriorated further though civil war (1992-1997). This negatively affected the process of economic reforms and development of the country.

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Between 1991 and 1997, Gross Domestic Product (GDP) decreased by more than 60 per cent. This increased the level of poverty within the regions (UN SPECA, 2003). On the other hand unemployment rose rapidly, which was also a key factor for the declining production level within the economy.[1] Political stability was restored after six years in 1997[2] and led to the first steps of implementation of market and structural reforms of the economy since independence. As a result, in a very short time Tajikistan has made substantial progress by implementing these agricultural reform policies.

Traditionally Tajikistan has been an agrarian country where more than half the labour force employed in the agricultural sector, and more than 70 per cent of the population living in rural areas and engaged in different agricultural activities. In particular, Tajikistan has great potential for growing cotton. Cotton is the dominant crop in Tajikistan's agricultural sector and has a large impact on the country's economy. The output of cotton is the largest source of export receipts, and it is often the only cash crop in Tajikistan, making it the main sector in poverty reduction for the rural cotton growing regions. Thus, this empirical research is the first ever model that analysis the Tajikistan agricultural sector.

The primary purpose of this research is to examine whether agricultural reforms have contributed positively to the efficiency of cotton production in Tajikistan. In this research the translog model of the Stochastic Production Frontier (SPF) was applied. Unbalanced panel data of 11-years covering the transition period 1992-2002 for 34 cotton-industrial regions were used to examine whether any significant effects were achieved in technical efficiency of this sector during the estimated periods. This estimates the magnitude of the impact of reforms on technical efficiency of cotton production, the most important and exportable crop in Tajikistan's economy. The findings reveal that the market reforms had a positive impact on technical efficiency of the cotton sector and contributed significantly to Tajikistan's economic development process.

Agricultural Reform Policies and Tajikistan's Cotton Sector

The agricultural sector is a key component of Tajikistan's economy in terms of exports, labour employment and potential for alleviation of rural poverty. In the 1990s the total area of arable land exceeded 4.3 million hectares. More than 660,000 hectares were irrigated and over 65 per cent of GDP came from crop growing sectors (State Statistics Committee of the Republic of Tajikistan (SSCRT), 2002). Hence this sector obtained about 12 per cent of export gains and employed more than 60 per cent of the labour force. Since the end of the civil war in 1997, Tajikistan has made substantial progress in pursuing agricultural reform policies. The key determinants

of agricultural reform policies in Tajikistan are identified as: 1) land reform; 2) trade (price) liberalisation; and 3) production efficiency (change in production organisation).

Land reform is the central policy in the agricultural sector of Tajikistan as this sector produces more than 60 per cent of the country's output. Therefore land reform has accelerated after the passing of two decrees in 1998 allowing land use rights to be traded. While the ownership of land still rests with the state, the long-term lease of land of up to 100 years for individuals and collective parties has been approved. Yet, its implementation varies from one region to another, which might impinge on the location-specific productivity in agriculture. There is also regional variance in crop patterns, theavailability of irrigated water, and farmers' attitudes and motivation. By February 2002, about 12,500 peasant (dehqan)[3] farms accounted for 45 per cent of total agricultural arable land. Overall, including the other forms of private farms, more than 51 per cent of arable land was in private hands by March 2002, which indicates substantial progress of land reform policies.

Initially, liberalisation covered practically all export categories items, except cotton and aluminium. As a result, administrative constraints and trade protective measures have been removed (for example the quota and licensing systems have been eliminated)[4]. However during the second stage of liberalisation, 1996-1997, the Government liberalised trade in cotton and at the same time established essential financial institutions, such as the Cotton Exchange, and the Tajik Universal Commodity and Raw Material Exchange. These measures not only allowed an increase of the agricultural export potential of the country but also changed the motivation of all cotton growing farms.

According to the Ministry of Agriculture reports (2003), by January 2000, about 400 state (sovkhoz) and collective (kolkhoz) farms had been restructured. More than 2675 dehqan farms developed as a result of reform policies (change in property rights and change in production organisation), with an average of more than 70 hectares of arable land. The State Adviser to the President of the Republic of Tajikistan on Economic Policy in his business visit to Canberra (May, 2002) emphasised Tajikistan's ongoing economic reforms, saying, 'almost about 50 per cent of total arable land has been shifted to private and dehqan farmers…. and in order to implement successfully the reform policies in Tajikistan's agricultural sector and get high level of agricultural production efficiency first, the Government is planning to gradually accomplish the restructuring and privatisation of the remaining, about, 250 state and collective farms by the end of 2005, and will restrict the public sector involvement in the agricultural sector...'(Author's personal communication with Mr. Faizullo Kholboboev, May 2002).

Initially, during the central planning economic system the country had been producing up to 1 million tonnes of cotton. After Tajikistan's independence in 1991

the cotton-growing sector received the right to arrange and sell its collected crop independently. However, initially production of cotton in the country declined 32 per cent in the five years of civil war, 1992-96. Since 1997, the first steps toward economic reform in agricultural sectors, particularly in cotton production, were accelerated. Overall, between 1997 and 2002 cotton production rose by 46 per cent, and especially during the last years (1999-2002) of intensive reforms, production of cotton increased substantially in the Central (108.1 per cent), South (78.1 per cent) and North regions (64.6 per cent). Earlier, by 2001, the privatisation of all 22 ginneries was successfully completed. However by 2001, about 75 per cent of raw cotton was still produced by state and collective farms (SSCRT, 2002). It must be noted that many regional administrative authorities, in fact, have opposed further farm privatisation because of the matter of losing the profits of scale economies and tax revenues if private farmers change crop patterns. Thus, land reform has been delayed in most cotton growing regions. It is expected that with further developments in land reform and production organisation, new investment will be attracted to this important sector of the country's economy.

In general Tajik cotton is highly valued in international cotton markets. For example, the price per tonne of Tajik fine-fibre cotton is 1.6 times high than average fibre types (SSCRT, 2002). For a country in agricultural transition like Tajikistan, cotton has proved to be an economically valuable crop, which has contributed to foreign currency inflow from overseas, a high level of export, poverty reduction, rural development and economic growth. Overall the cotton sector generates a significant share of government revenue. A transition toward more competition in international markets and hence greater efficiency in distribution of inputs, growing, processing and marketing of cotton, should be favourable for Tajikistan to increase production further and also expand exports of this crop (called 'white gold' by Tajik farmers). The long-term strategic goal in production of cotton is to raise and support its contribution to rural poverty reduction through employment, farmers' income accumulation across all cotton growing regions, and raising exports and government revenue. Thus this empirical research compares administrative regions for technical efficiency of cotton production and productivity since Tajikistan's independence to the present using Panel-Data analysis estimation.

Model Specification, Data and Variables

Model Specification

Initially Aigner et al. (1977), and Meeusen and van den Broeck (1977) developed the stochastic production frontier (SPF) function.[5] This study follows the Battese and

Coelli (1995) panel-data model with a translog term of the stochastic production function. Firstly, to verify the functional form and specification the generalised likelihood-ratio tests are used. The exact critical values for the test statistic from a mixed χ - squared distribution (at the 1 per cent level of significance) are drawn from the statistical table of Kodde and Palm (1986). Functioning as a pre-test the null hypothesis of the Cobb-Douglas form of the production function is tested against a translog model. The result of the statistical test is equal to $\chi^2_{10} = 194$ compared to a critical value of 22.5 shows that a translog model of the SPF function is preferred to be the appropriate model for the estimation of the data available in the 34 cotton growing regions of Tajikistan. Further, by implementing equation (1), the unbalanced panel data set for the cotton industry regions of Tajikistan are specified. The log of output in the cotton sector in region *i* at time *t*, Ln Y_{it} can be formulated as:

$$Ln(Y_{it}) = \beta_0 + \sum_j \beta_j X_{jit} + \sum_j \sum_n \beta_{jn} X_{jit} X_{nit} + \sum_n \beta_n D + \beta_j T + V_{it} - U_{it} \qquad (2)$$

where the explanatory variables are (logs of) area of cotton sown, the labour force, number of tractors, fertiliser and the respective cross products. The variables D are dummies for the three cotton growing provinces and T is a time trend. The regional (North, Central and South provinces) - dummy variables are used to predict the effect of each cotton growing province and a time trend included in equations to capture time-variant effects. The number of tractors as a specific measure of capital is used in the cotton industry. Also, workers in the cotton sector are taken to be proportional to cultivated area. The V_{it}'s are assumed to be independent and identically distributed as normal random variables with mean zero and variance, σ_v^2 , independent of U_{it}, and the U_{it}'s are non-negative technical inefficiency of production that are assumed to be independently distributed, such that uit is obtained by truncation (at zero) of the $N(\mu_{it}, \sigma^2)$ distribution. The regional- specific factors (Z_{it}) are used in the technical inefficiency model, as:

$$U_{it} = \delta_0 + \delta_1 civilwar + \delta_2 av.farmland + \delta_3 av.tracfarm + \delta_4 refpol. + \delta_5 soildif \quad (3)$$

where the specific factors are: a dummy for regional civil war (with value 1 where the variable for region is in a war zone,[6] zero otherwise); average farms cultivated land; average number of tractors per farm; dummy of implementing reform policies (a dummy with value one the year of implementing reform policies and a dummy with value zero otherwise), and dummy for regional soil differences.[7] The average farm's cultivated area of cotton and the average farm's number of tractors are included to measure the effects on technical efficiency from the introduction of regional strategies and in the neoclassical production function and also to measure the cultivated lands' cotton and tractor use capacities.

As the coefficients of the translog SPF model (equation 2), do not have a straightforward interpretation, by taking the derivative of the logarithm of output with respect to the log of the *n*-th input variable, the elasticity of output relative to input variables are found, and en are seen to be the mean values of relevant data points. This can be derived as:

$$\varepsilon_n = \frac{\partial \ln Y}{\partial \ln X_n} = \beta_n + 2\beta_{nn} \ln \overline{X_n} + \sum_{j \neq n} \beta_{nj} \ln \overline{X_{ji}} \tag{4}$$

where $\overline{X}$ is the input variables' mean used in the production frontier. The ε_n elasticity, indicates the responsiveness of output to a one per cent change in the *n*-th input. Here the measure for returns to scale, indicating the percentage change in output due to a proportional change in inputs, is estimated as the total of output elasticities to all inputs. Where this estimate is >1, =1, or < 1, it will have increasing, constant, or decreasing returns to scale, respectively. For example, assuming the restriction that the output elasticities of the inputs are equal to one, can confirm the test for accepting CRS.[8]

Finally, indices of convergence are measured to see whether the ranks of cotton growing regions by technical efficiency differ significantly across the estimated years. Following Jha et al. (1999), Kendall's coefficient of concordance is calculated to keep in line the mobility of individual regions within the distribution of efficiencies over the period of time.[9] The main reason for calculating this is to find if the regions that were inefficient earlier are still inefficient or whether there has been any convergence. A coefficient of concordance, *W*, is defined as an index of the divergence of the actual agreement of ranks from the maximum possible (perfect) agreement. Thus W is calculated as:

$$W = s / \left\{(1/12)\left(k^2\right)N\left(N^2 - 1\right)\right\} \tag{5}$$

where, s = sum of the squares of the observed deviations from the means of R_j (the sums of the ranks obtained by particular regions in different years). The value of the rank concordance index (*W*) varies between 0 and 1 and is computed first for the two sets of rankings (that is first two years), then for the first three years and so on, until all the years are covered.

Data and Variables

This study employs an unbalanced panel data set, which consists of thirty-four cotton producing regions of Tajikistan's agricultural sector between 1992 and 2002, 342 observations in total. The data come from samples of small-scale and large-scale

cotton growing regions (Table 1 in Appendix) in the three provinces of Tajikistan (North, Central and South).

The data sets include aggregate cotton output and four main inputs: the cultivated area sown to cotton, the labour force, machinery (the number of tractors), and chemical fertiliser. Secondary production data, which includes total annual output (in tonnes) for the 34 cotton growing regions, obtained from the State Statistics Committee of the Republic of Tajikistan (SSCRT). The input data are obtained form the Statistical Office of the Ministry of Agriculture of Tajikistan.

The output of cotton is measured in tonnes (1000 kg = 1 tonne), with substantial change from year to year. This is because of the changes in inputs and cultivated area of cotton. Average yield per region for 1992-2002 is about 1600 kg/ha per year. Overall the average output of cotton is 432000 tonnes/year (SSCRT, 2002). In this empirical research four inputs (labour, land, fertiliser and tractors) are included. First, labour input is measured as total female and male labour engaged (including hired) in the cotton sector. The ages of the workers are not significantly different since the average age of farmers (workers) is about 34 years old. Second, land is measured as net-cropped area (cultivated area). The cultivated area for cotton has changed significantly within areas and the change in non-cotton cultivation patterns also has impact on the technical efficiency of cotton growing regions. Third, fertiliser input is measured as the total tonnes of nitrogen, superphosphate and potassium used in cotton growing region farms. Fourth, the number of tractors, including both government (collective and state farms) and privately owned, measures machinery (tractor) input. Other variables such as the interaction term of log of input variables are specified for better technical efficiency effects in the model estimation. Also the regional (North, Central and South provinces)-dummy variables and the time trends are included in the estimation of the SPF model. A summary of the values of the variables used in these analyses is presented in Table 2 (Appendix). Statistical reports for the main cotton sector variables for the thirty-four regions are listed in Table 3 (Appendix).

Empirical Results and Discussion

The coefficients of parameters for equation (2), the stochastic production frontier model, and for equation (3), the technical inefficiency model, are obtained from using the maximum-likelihood estimation (MLE) program, Frontier 4.1 (Coelli, 1996). This program is consistent with a three-step econometric procedure,[10] which is OLS estimates, grid search of likelihood function and maximum likelihood estimates. Results from using these two equations are shown in Table 1. All

estimated input variables are statistically significant except the variable of interaction between land and capital (lnland*lntractor).

Table 1: Estimated Parameters of the SPF and Technical Inefficiency Models

SPF model	MLE		OLS		
Variable	Coefficient	T-ratio	Coefficient	T-ratio	
constant	-10.6	-21.24*	-10.3	-0.000001	beta 0
lnLand	-0.64	-3.74*	-0.996	-1.07	beta 1
lnLabor	1.32	4.98*	1.62	1.37***	beta 2
lnTractor	-0.84	-5.66*	-0.89	-0.77	beta 3
lnFertiliser	1.56	3.6*	1.56	0.76	beta 4
lnLand2	0.27	8.62*	0.32	1.82**	beta 5
lnLand*lnLabor	-0.24	-5.28*	-0.30	-1.39***	beta 6
lnLand*lnTractor	-0.00008	-0.003	-0.003	-0.019	beta 7
lnLand*lnFertil-r	-0.22	-3.13*	-0.24	-0.68	beta 8
lnLabor2	0.03	5.52*	0.037	0.83	beta 9
lnLabor*lnTract.	0.072	2.73*	0.079	0.69	beta 10
lnLabor*lnFertil.	0.034	2.84*	0.043	0.52	beta 11
lnTractor2	-0.024	-1.44***	-0.024	-0.19	beta 12
lnTractor*lnFert.	0.088	2.43**	0.09	0.46	beta 13
lnFertiliser2	-0.027	-1.73**	-0.021	-0.15	beta 14
ttrend	-0.01	-2.36**	-0.009	-0.25	beta 15
d.Central regions	11.06	22.06*	15.51	0.0000021	beta 16
d.North regions	10.94	21.85*	9.55	0.0000013	beta 17
d.South regions	10.83	21.64*	10.38	0.0000015	beta 18
Tech.Inef. model					
constant	-6.54	-5.19*			delta 0
civil war	1.39	2.33**			delta 1
av.farmsland	-0.0055	-7.15*			delta 2
av.farmstractor	0.059	3.42*			delta 3
reform policies	-1.14	-4.52*			delta 4

diff.reg.soil	3.06	2.49*			delta 5
sigma-squared	1.57	10.9*	4.204		sigma-sq
gamma	0.979	193.7*			gamma
log likelihood f-n	-60.2		-0.789.5		logl.fun-n
LR test 1-side error	1458.5				LR test
Mean Technical Efficiency	0.814				

Notes: *, **, and *** indicate statistical significance at the 0.01 level, 0.05 and 0.10 level respectively and t-ratio is asymptotic
Source: Author's own calculation

Although the output of cotton is highly dependent on the country (region) specific effects and as well as random errors (for example seasonal weather effect), the relationship between sown period and future output is not clear. Figure 1 (Appendix) shows the difference between average and frontier output, which is called technical efficiency.

The low values for average annual output in 1995-97 and 1999 follow the consequences of civil war, inefficient use of capital input and seasonal weather affect results. Weather conditions play a key role in growing cotton. Further, including the regional (North, South and Central provinces)-dummies in the SPF model adjust the level of estimated maximum efficiency of output as well as the estimated output elasticities.

First, the tests of hypotheses are analysed. The generalised likelihood-ratio (LR) tests of various null hypotheses which include restrictions on the variance parameter, γ, in the SPF model, and δ-coefficients in the technical inefficiency model, are given in Table 2.

From the first and second null hypotheses in the test it is clear that technical inefficiency effects are not presented, those inefficiency effects are stochastic and this null hypothesis is rejected. Hence, the OLS function is not a sufficient description for the analysis. This is also indicated from the estimated variance parameter (gamma) not being equal to zero ($\gamma \neq 0$). The third null hypothesis, that the intercept and all the coefficients, which had relations with various regions and country specific variables, are zero in the technical inefficiency model, is rejected.[11] Finally, for the fourth null hypothesis, (which is less restrictive compared to the others) it is also rejected that, except for the intercept, all other parameters of the technical inefficiency model are equal to zero.[12] From the specifications of the stochastic frontier model (equations 2 and 3), overall the LR (Likelihood Ratio) test

results show that the technical inefficiency effects are stochastic and are presented significant in defining the variation in productive achievement of Tajikistan's cotton growing regions.

Table 2: Generalised Likelihood Ratio Tests for Parameter Restrictions

Null Hypothesis	LR Statistic	Critical Value	Decision
$\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	94.8	19.38*	reject H0
$\gamma = 0$	51.7	8.3*	reject H0
$\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	71.4	17.75*	reject H0
$\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	25.86	16.07*	reject H0

Note: The critical values of hypotheses are taken from Kodde and Palm (1986).
* indicates statistically significant at the 0.01 level
Source: Author's own calculation

Second, results in Table 4 (Appendix) show that the estimated technical efficiencies for Tajikistan's cotton growing regions range from a minimum 0.27 to 1.00 maximum, with a mean efficiency of 0.814. Figure 2 (Appendix) shows the frequency distribution of the

estimated technical efficiencies. The frequency distributions diagram shows that the 34.2 per cent of cotton growing regions have technical efficiency indices of 0.9 and above and 33.6 per cent of regions have technical efficiency indices of 0.8 to 0.9. Hence, almost 68 per cent of the sample regions have a technical efficiency index of 0.8 and greater, indicating that, between 1992-2002, a considerable proportion of these regions performed close to the efficiency frontier. And sample inefficiency of production predominates among the remaining 32 per cent of the cotton growing regions in the country.

Third, the results for the technical inefficiency model reveal that all the estimated regional specific effect parameters of technical inefficiency are highly significant but have different signs. As shown in Table 1, based on the asymptotic t-ratios, the average area of cotton sown (δ_2), and coefficient of economic reform policies (δ_4), both have a positive significant effect on technical efficiency (hence both variables have a negative significant effect on the technical inefficiency model). Hence, regions that implemented incentive market reform policies (or started earlier land and price liberalisation reforms) tend to be more efficient than those regions that have not.[13]

It is clear from estimated model, that technical efficiency has substantially risen across all regions during these years. On the other hand, the coefficient of regions involved in civil war (δ_1), the coefficient of average number of tractors (δ_3) and the coefficient of the regional soil differences (δ_5) are all positive in the estimated

technical inefficiency model. This means that, the coefficients of δ_1 (civil war destroyed the infrastructure of those cotton growing regions where it occurred and as a result cotton sector efficiency substantially fell), δ_3 (collective and state farms were inefficiently using a large number of tractors, which brought high costs for technical efficiency in the output of cotton) and δ_5 (regional soil differences is the main factor, having a larger negative impact) all have negative effects on the technical efficiency of cotton growing regions. The value of gamma is γ =0.979 and highly significant. Estimates of the residual variation are better because of inefficiency effects and influence variance in random effects (ν_{it}).

Fourth, the results are about elasticities and returns to scale. The output elasticities are measured at means of relevant data points. The results of estimated elasticities in Table 3 are obtained from equation (4).

Table 3: Output Elasticities for Cotton Production in Tajikistan

With respect to:	Elasticity
Land	0.09
Labour	0.67
Tractor	-0.48
Fertiliser	0.85

Source: Author's own calculation

The values of output elasticities for all inputs such as land, labour, capital (number of tractors used) and fertiliser are positive. However, all elasticity estimates are significantly different from zero. The highest elasticity is evaluated for fertiliser (0.85), then followed by labour (0.67) and land (0.09), and the lowest is for number of tractors (-0.48). The returns to scale for Tajikistan's cotton growing regions are calculated as the sum of output elasticities for all inputs, calculated as about 1.13 ($\Sigma\varepsilon_n = 1.13$). Hence, based on the data between 1992 - 2002, Tajikistan's cotton industry can be defined by increasing returns to scale.

Finally the results on rank convergence show that the critical value of chi-square (at 5 %) exceeds the computed value only for the first entry. In all other cases, the null hypothesis of no agreements among the ranks is rejected. Consequently, there has been quite notable stability in ranks across these cotton-growing regions in regards to variables that determine technical efficiency. The Kendall tests statistics for the 34 cotton growing regions during the transition period are reported in Table 4.

Table 4: Rank Concordance among Cotton Growing Regions (1992-2002)

Number of rounds	W	Chi-square
k=2	0.2945	16.49*
k=3	0.3022	25.36
k=4	0.2949	33.03
k=5	0.2364	35.46
k=6	0.2005	38.49
k=7	0.2032	45.52
k=8	0.1868	49.32
k=9	0.2463	66.51
k=10	0.2505	75.14
k=11	0.2584	85.28

Note: An asterisk (*) denotes acceptance of the null hypothesis at 5%.
Source: Author's own calculation

Implications and Conclusions

The estimated model for technical inefficiency effects provides evidence to improve performance of the cotton growing regions in Tajikistan. A comparison with cotton production, which was mandated under the planned economy and thus had been the major crop of Tajikistan, might show how farmers' motivation has changed during the transition period as the incentive structure has increased market participation, especially in the last years. For example, the results show that, with everything else holding constant, regions in the sample could increase yield by changing their targeting strategies in the short-run, and reaching a high level of technical efficiency in major cotton growing regions. These changes can achieve more beneficial outcomes in the long-term.

An agricultural reform policy is very important for economic development and poverty alleviation in rural area of Tajikistan. It will intensify production and allow a larger share of the international price to be passed through to cotton growing farmers. However the cotton producing sector is facing difficult times due to the lower price of cotton in the world market, which is a result of high subsidies to cotton producers in the European Union and the USA.[14] On the other hand cotton is a main crop in the strategy of rural

economic development in many developing or transition country (such as Tajikistan), in its importance for the exports of these countries. The prospects for economic development and poverty reduction would be significantly better if the cotton growing industrial countries could remove subsidies for this product.

This research of the technical efficiency of the SPF of cotton producing regions in Tajikistan is based on the unbalanced panel data set of 342 observations among thirty-four regions for the years 1992 to 2002. The results reveal that, on average, all estimated regions are more technically efficient, with significant variance. The mean technical efficiency for this sample of panel data is estimated to be 81.4 per cent. The main specific factors that could influence the technical efficiency of Tajikistan's cotton-growing sector were: average area of farmland; civil war; market reform policies; average number tractors; regional soil differences; and random effects such as weather conditions or floods. The estimated results show that despite negative effects from factors, such as, regions were involved in civil war, average farms' number of tractors and regional soil differences on technical efficiency, the coefficient of average area of farmlands and introducing agricultural reform policies both have a positive significant effect on technical efficiency all 34 cotton growing regions. Hence, implementing incentive reform policies (land reform, price liberalisation and production organisation) lead to a high level of efficiency across all regions. Thus with a rise in technical efficiency of regions, cotton harvests at some level could get closer to the output frontier. Results also illustrate, that rank convergence takes many years, and that there is the presence of increasing returns to scale in cotton growing regions during the estimated transition period (1992-2002).

Due to data constraints, this empirical research focuses only on technical efficiency despite the importance of allocative efficiency. Hence, further research on this sector is recommended to extend estimation analysis to allocative efficiency and to combine both technical and allocative efficiencies. Doing this could better present the effects of agricultural reform policies on total economic efficiency of Tajikistan's cotton growing regions.

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NOTES

[1] The average monthly salary declined to $10 US dollars (for more detail see UN SPECA, 2003).

[2] After the signing of a peace agreement between the Government and the Tajik United Opposition, political stability has been restored and a coalition government (70 % to 30% respectively) was formed.

[3] The operations of *dehqan* farms are hindered by unsecured property rights, a lack of financing for key inputs and equipment, ongoing intervention by local authorities regarding production decisions, a complicated and unfriendly tax environment, a crumbling irrigation system, and a general lack of basic

agricultural extension services. Nonetheless, despite numerous problems, preliminary evidence suggests that *dehqan* farms are performing better than state farms.

[4] For instance, compared to neighbouring countries (Turkmenistan and Uzbekistan), there is no government quota for cotton production and also the government does not deal with the cotton's selling price. However, production quotas and incorrectly lower prices on cotton are still imposed by many regional (local) bureaucrats, who employ numerous plans at their removal such as obstructing farmers' access to external markets and restraining inputs from farmers (mostly from collective farms and dehqan farms) who decline to grown cotton crops (Author's personal communication with collective farm, state farm and dehqan farm representatives, January 2002).

[5] Mathematically, it can be written as: $Y_{it} = f(X_{it}, \beta, t)e^{v_{it}-u_{it}}$

where i indicates regions (farms), t time, Y_{it} denotes output, Xit indicates a vector of inputs, β is a vector of parameters to be estimated and t is a time trend. As usual, in terms of error, ν is assumed to be independently and identically distributed as $N(0,\sigma_u^2)$ and takes random variation in output due to factors outside the control of the farm. The error term uit, is counted as being firm-specific, non-negative random variables, independently distributed as non- negative truncations (at zero) of the distribution of $N(\mu_{it},\sigma_u^2)$.

[6] Between 1992 and 1997 major cotton growing regions suffered from the country's civil war, which had a negative effect on all collective (state) farms and private farms. The list of these regions is marked (*) in Table 1 (Appendix).

[7] Land reform has been legalised since 1997, after the peace declaration between the government and opposition. However most agriculture reforms started to be implemented from 1998.

[8] For CRS-the constant returns to scale assumption in (2), the translog term of the SPF imposes a few linear restrictions in the parameters of the model such as: $\beta_1+\beta_2+\beta_3+\beta_4=1$; $2\beta_{11}+\beta_{12}+\beta_{13}+\beta_{14}=0$; $\beta_{12}+2\beta_{22}+\beta_{23}+\beta_{24}=0$; $\beta_{13}+\beta_{23}+2\beta_{33}+\beta_{34}=0$; $\beta_{14}+\beta_{24}+\beta_{34}+2\beta_{44}=0$ (for more detail see Boisvert, 1982).

[9] For more detail see Boyle and McCarthy (1997).

[10] The OLS estimates come first, followed by the grid search, which defines a likelihood function for values of gamma (γ) between zero and one, with regulations to OLS estimates of intercept and σ^2. Other values of parameters are restricted to be equal to zero in the second step. Lastly, the best likelihood values selected in the second step are used as starting values in a quasi-Newton iterative procedure to constitute maximum likelihood estimates at a global maximum point of the likelihood function (for more information about the Frontier 4.1 program see Coelli, 1996).

[11] Here the technical inefficiency effects used have half-normal distribution with mean equal to zero.

[12] Here the technical inefficiency effects used have the same truncated-normal distribution where mean is equal to δ_0.

[13] A number of regional governors still support the ineffective collective farms and would not be happy to implement 100 per cent land reform in the agricultural sector of economy.

[14] The Associated Press has recently released a report that, during the period August 1999-July 2003, the USA subsidised only its cotton growing sector by about $12.5 US billion. (http://www.gazeta.ru/lenta_body.shtml, 27/04/04)

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Appendix

Table 1: Tajikistan's 34 Cotton Producing Regions

North: (Leninobod)	1) Asht, 2) Ayni, 3) Konibodom, 4) Gafurov, 5) Zafarobod, 6) Mastchoh, 7) Rasulov, 8) Nov, 9) Gonchi and 10) Istaravshan
South: (Khatlon)	11) Kulob, 12) Vosei, 13) Moscva, 14) Farkhor, 15) Dangara, 16) Gozimalik*, 17) Khojamaston*, 18) Bokhtar*, 19) Vakhsh*, 20) Sarband*, 21) Jilikul*, 22) Kolkhozobod*, 23) Kumsangir*, 24) Panj*, 25) Shahrituz*, 26) Kabodiyon*, 27) Bishkent*, 28)Yovon* and 29) Soviet
Central (NMTJ)	30) Tursunzoda, 31) Hisor, 32) Sharinav, 33) Lenin* and 34) Kofarnihon*

Note: NMTJ-Nohiyahoi Markazii Tobei Jumhur. Regions, which suffered from the civil war, are indicated by *.
Source: Statistics Committee of the Republic of Tajikistan, 2002.

Table 2: Summary of Inputs and Regional Specific Variables

Variables	Description	Sources
Land (X1)	Total cultivated land for cotton (hectares)	SSCRT (2002)
Labour (X2)	Number of workers in cotton sector	-
Capital (X3)	Number of four wheel tractors	Ministry of Agriculture
Fertiliser (X4)	Fertiliser used, kg per hectare	SSCRT (2002)
Civil War (Z1)	Dummy for regions suffering from civil war	SSCRT (2002)
Av.farmland (Z2)	Average area of farmland for cotton	-
Av.tractorfarm (Z3)	Average number of tractors per farm	-
Ref.policies (Z4)	Dummy for years of reform policies	-
Reg. soil diff. (Z5)*	Dummy for soil differences in regions	-

* A binary variable for regional soil differences is used to indicate soil conditions, 1 for the less cotton growing regions (i.e. regions with the poor quality of land) and zero for others.
Source: Author's own calculation

Table 3 Summary Statistics for Key Variables

Variable	Units	Mean	Std.Dev.	Min	Max
output	tonnes	13645.16	8460.63	43	41953
land	hectare	8232.54	4273.13	10	17785
labour	peasant	7438.31	4198.97	60	22917
capital	tractor	504.00	174.76	117	885
fertiliser	tonnes	127.65	69.43	11	623.1

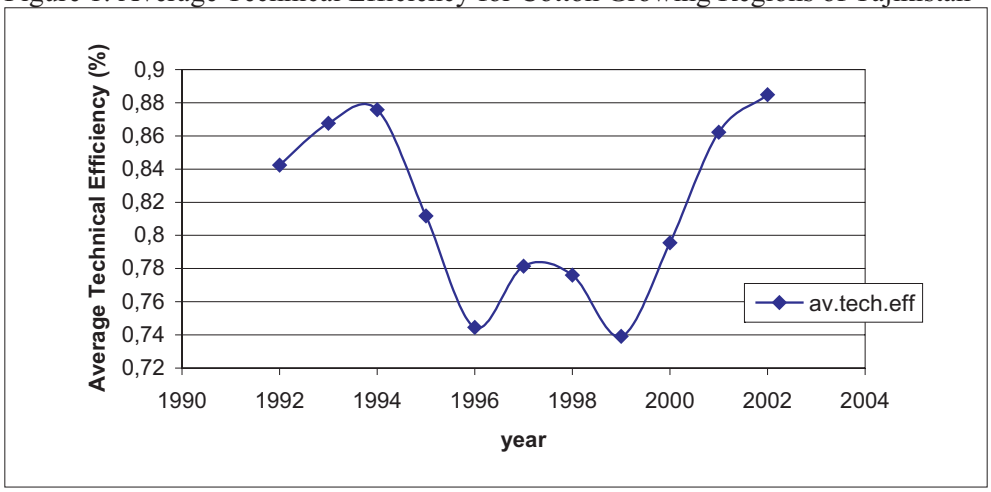
Source: Author's own calculation

Table 4: Estimated Technical Efficiencies of Cotton for Regions of Tajikistan

#Reg	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.89	0.89	0.68	0.67	0.58	0.60	0.60	0.66	0.73	0.67	0.69
2	n.a.	n.a.	n.a.	n.a.	n.a.	n..a.	n.a.	0.84	n.a.	n.a.	0.57
3	0.92	0.91	0.91	0.90	0.91	0.93	0.93	0.92	0.94	0.93	0.91
4	0.88	0.85	0.83	0.87	0.84	0.89	0.88	0.90	0.92	0.94	0.92
5	0.82	0.76	0.64	0.57	0.49	0.68	0.61	0.58	0.79	0.81	0.90
6	0.91	0.91	0.89	0.80	0.86	0.91	0.86	0.85	0.84	0.93	0.91
7	0.91	0.90	0.92	0.93	0.91	0.93	0.92	0.92	0.90	0.91	0.92
8	0.91	0.85	0.88	0.89	0.77	0.89	0.84	0.94	1.00	0.91	0.91
9	n.a.	n.a.	n.a.	n.a.	n.a.	0.43	0.27	0.34	n.a.	n.a.	0.92
10	n.a.	n.a.	n.a.	n.a.	n.a.	0.83	0.60	0.89	0.90	0.49	0.94
11	0.93	0.94	0.94	0.94	0.90	0.89	0.83	0.92	0.93	0.95	0.95
12	0.93	0.93	0.92	0.91	0.86	0.84	0.79	0.58	0.74	0.84	0.91
13	0.94	0.93	0.91	0.88	0.80	0.87	0.83	0.84	0.91	0.92	0.92
14	0.92	0.91	0.89	0.68	0.68	0.85	0.72	0.61	0.68	0.86	0.87
15	0.82	0.94	0.84	0.69	0.73	0.68	0.67	0.66	0.55	0.81	0.84
16	0.88	0.85	0.91	0.76	0.47	0.72	0.87	0.69	0.51	0.78	0.90
17	0.80	0.93	0.87	0.65	0.54	0.59	0.85	0.65	0.54	0.81	0.82
18	0.85	0.87	0.92	0.83	0.82	0.87	0.89	0.80	0.79	0.90	0.89
19	0.53	0.85	0.88	0.77	0.81	0.80	0.83	0.82	0.91	0.88	0.93
20	n.a.	n.a.	n.a.	n.a.	0.86	0.75	0.91	0.90	0.90	0.91	0.94
21	0.78	0.87	0.90	0.77	0.66	0.65	0.85	0.72	0.56	0.92	0.87
22	0.81	0.79	0.88	0.72	0.86	0.82	0.87	0.81	0.87	0.93	0.80
23	0.71	0.90	0.92	0.89	0.74	0.72	0.90	0.72	0.62	0.82	0.91
24	0.88	0.92	0.89	0.77	0.72	0.76	0.73	0.57	0.68	0.74	0.94
25	0.89	0.90	0.89	0.79	0.48	0.62	0.78	0.65	0.81	0.94	0.94
26	0.91	0.95	0.90	0.83	0.67	0.80	0.89	0.84	0.88	0.91	0.93
27	n.a.	n.a.	n.a.	n.a.	0.77	0.86	0.79	0.66	0.69	0.84	0.92
28	0.78	0.92	0.92	0.75	0.69	0.85	0.84	0.67	0.84	0.90	0.93
29	0.93	0.88	0.88	0.89	0.58	0.55	0.71	0.40	n.a.	n.a.	n.a.
30	0.89	0.94	0.89	0.93	0.91	0.91	0.93	0.72	0.86	0.93	0.94
31	0.81	0.73	0.89	0.91	0.90	0.89	0.81	0.84	0.90	0.94	0.93
32	0.84	0.80	0.92	0.91	0.78	0.79	0.72	0.81	0.91	0.90	0.85
33	0.64	0.70	0.76	0.74	0.71	0.69	0.54	0.69	0.73	0.83	0.83
34	0.72	0.64	0.93	0.90	0.78	0.93	0.55	0.72	0.83	0.88	0.85

Note: #Reg – Cotton growing region – number corresponds with list in Table A3.1.
Source: Author's own calculation

Figure 1: Average Technical Efficiency for Cotton Growing Regions of Tajikistan



Source: Author's own calculation

Figure 2: Frequency Distribution of Technical Efficiencies