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Paper Title

An Analysis of the Technical Efficiency of Cotton Farmers in the Punjab province in Pakistan

by

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Abstract

In this paper we analyse the technical efficiency of cotton farmers in the Punjab Province in Pakistan. Technical efficiency is measured relative to a stochastic frontier production function (SFPF). The estimated model includes a function in which technical efficiency is made an explicit function of firm specific factors (involving the levels of education and experience of farmers and other factors). For the purpose of analysis, survey data was collected for the 1996-97 season. Analysis is done on a district basis and the mean technical efficiencies obtained are 76, 78, 77 and 83 per cent for the districts of Arifwala, Bahawalpur, Multan and Rahim Yar Khan respectively.

This study suggests that there is considerable room for productivity gains for the farms in the sample through better use of available resources. Results indicate that the incidence of virus on cotton crop has a significant influence upon efficiency levels, while age, education, experience, extension advice, access to credit, land ownership, tractor ownership, sowing time and off-farm income activity all have little influence on efficiency levels.

Keywords: Technical efficiency, stochastic production frontier, and cotton farms.

1. Introduction

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NOTE: Preliminary draft only, please do not quote

Agriculture is the largest sector of Pakistan’s economy. The economy of Pakistan mainly depends on agriculture and agro-based industry. The share of agriculture in GDP was about 50 per cent at the time of independence in 1947, as agriculture was the only developed sector at that time. The other sectors developed with the passage of time and hence the share of agriculture in Gross Domestic Product (GDP) has fallen (Looney 1997). In 1997 agriculture still remained the largest contributor to the GDP, its contribution was about 24 per cent. It is still the biggest sector as it employs about 50 per cent of the labour force, supports directly or indirectly approximately 70 per cent of the total population and contributes 80 per cent of foreign exchange earnings. It is thus evident that the welfare of the vast majority of the population critically depends on efficient harnessing of the agricultural resources of the country (Government of Pakistan 1997).

Agricultural production in Pakistan is dominated by the crop production sector, which accounts for more than 62 per cent of the value of agricultural production. Cotton is the second most important crop after wheat. Cotton is cultivated on 10 per cent of the total cropped area. The province of Punjab is the main cotton producing area in Pakistan. It contributes about 89 per cent towards total cotton production. Cotton contributes to the overall well being of the economy in many ways. It provides raw material to cotton ginning units, spinning units, textile mills, hosiery industry and vegetable oil mills. It is also a major export item from the crop sector, since it directly or indirectly contributes about two thirds of Pakistan's total export earnings. It is exported not only in raw form, but also in semi manufactured (eg. yarn) and manufactured forms. Therefore, the cotton crop is an important contributor to the economy of the country. Hence by increasing cotton production in Pakistan, we can increase the well being of millions people in the country (Ahmad & Battese 1997).

The area under cotton cultivation has increased by 81 per cent during the period from 1971-72 (1.74 million hectares) to 1996-97 (3.15 million hectares). It has remained almost constant after 1991-92. There has been a lot of variation in the yield since 1971-72 when it was 897 kg per acre. It decreased to 573 kg's in 1976-77, followed by upward trend to 987 kg's in 1982-83 (Government of Pakistan 1996). In 1983 the withdrawal of the subsidy on pesticides by the government also effect the cotton yield. In that year the yield was 548 kg's. 1992-93 was the best year for cotton when the average per acre yield was 1897 kg's (Government of Pakistan 1996).

A failure in cotton production can effect the entire economy of the country (Government of Pakistan 1997). The achievement of productivity gains in agriculture is an important challenge for Pakistan. Agricultural output is not keeping up with the fast population growth rate, which is 2.7 per cent per annum. It is difficult for the economy to cope with domestic food requirements. Like most developing economies, yields of most of crops in Pakistan are much lower than potential yields and there is also a wide yield gap between progressive and non-progressive farmers in Pakistan (Government of Pakistan 1997; NCOA 1988).

Since the 1960's it has been the policy agenda of the government to increase domestic food output by increasing the use of conventional resources such as irrigation water and fertiliser, and adoption of new technologies such as improved crop varieties, pesticides and mechanisation of farm power (Malik, Aftab & Sultana, 1994; NCOA 1988).

Efficiency is a very important factor for productivity growth especially in developing agricultural economies, where they have limited resources and less opportunities to adopt new and mechanical technologies (Ali & Chaudhry 1990).

Thus far no rigorous efficiency study has been conducted on Pakistani cotton farms. The main objective of this paper is to estimate the technical efficiency of the cotton farms in Pakistan using stochastic frontier production function (SFPF) methods. We also seek to explain differences in technical efficiencies using factors such as farmer age and education levels, etc.

The structure for rest of the paper is as follows. Section 2 describes SFPF methods. Section 3 discusses the data. Section 4 presents the empirical results. The last section provides a summary and conclusion.

2. Analytical Framework

Farrell's (1957) seminal work on efficiency measurement led to the development of several approaches to efficiency and productivity analysis. Numerous studies have estimated technical efficiencies of agricultural producers in recent years. The stochastic frontier production function (SFPF) methods proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) are the methods which have been most often used in agricultural applications (Coelli 1995).

2.1 Stochastic Frontier Production Function

Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) independently proposed the stochastic frontier function for cross-sectional data. The first application of this method to farm level data on agriculture was by Battese and Corra (1977).

The deterministic frontier model for cross-sectional data is defined as,

(1) $$\ln Y_i = f\left(X_i, \beta\right) + V_i - U_i, \quad i = 1,2,..........., N$$

In this equation Y_i is the actual production level of the i-th firm, *f(.)* is a suitable functional form. X_i is the vector of inputs of the i-th firm, β is the vector of unknown parameters to be estimated, associated with X variables. The $V'_i s$ are assumed to be independent and identically distributed random errors following a normal distribution with zero mean and variance σ_v^2. The random errors, which account for measurement errors in production and other random factors which, are not under management control, such as weather etc. The $U'_i s$ are the technical inefficiency effects, which are associated with the technical inefficiencies of firms and were assumed to be identically and independently distributed as either exponential or half-normal (ie. non-negative truncation of the $N(0,\sigma^2)$ distribution) random variables in the above mentioned papers. The observed output, Y_i , is bounded above by the stochastic quantity, $f(X_i,\beta)exp(V_i)$.

The technical efficiency of farm *i*, is defined as

(2) $$TE_i = exp(-U_i)$$

This is predicted using the conditional predictor presented in Battese and Coelli (1988) which generalises the results of Jondrow et al (1982).

Factors Affecting Technical Inefficiency

Battese and Coelli (1995) proposed a model where the inefficiency error was influenced by a vector of firm characteristics z_i. In the cross-sectional case, this model is as defined in equation (1), except that the U_i are iid distributed as $\left|N\left(z_i\delta,\sigma^2\right)\right|$ where δ is vector of unknown parameters to be estimated and σ^2 is also an unknown parameter to be estimated. The maximum likelihood method is used to estimate the unknown parameters $(\beta,\ \delta,\ \sigma^2, \sigma_v^2)$. This was done by using computer program FRONTIER, 4.1c (Coelli 1994).

3. Data

Administratively, the Punjab province is divided into four agricultural zones, namely Barani (arid), Rice, Central (mixed cropping zone) and Southern (Cotton zone) (Ahmad, Chaudhry & Hassan 1994). This province holds a peculiar position among all the other provinces in the country, especially in an agricultural context. It occupies about 25 percent of the land area of Pakistan and agriculturally it is the most productive province (Looney 1997).

Pakistan's agriculture is based predominantly upon one of the world's oldest and largest contiguous gravity flow irrigation systems in the world, the "Indus Basin irrigation system". The problem is that the system is very old and it needs some major changes like lined canal and water channel system. Due to the present system almost 45 % of irrigation water is wasted through seepage and percolation, which give birth to the twin problems of water logging and salinity. (Mahmood & Walter, 1990).

The major crops in the province are cotton, wheat and orchards. Data on farm production, input and costs were collected via a questionnaire administered to total 301 cotton farms for one agricultural year, 1996-97. The data used in this paper comes from a random sample of cotton farms from four districts of the Punjab province. Cotton production is concentrated in the Southern zone of Punjab and for this study the data was collected from three districts (Bahawalpur, Multan and Rahim Yar Khan) from the Southern zone (cotton zone) and one district (Arifwala) from Central (mixed cropping zone). Districts and respondents were selected randomly from 5 to 7 villages randomly selected from each district. The number of farmers surveyed in each district was 76, 75, 73 and 77, respectively.

The output (Y), inputs (x's) and firm-specific factors (z's) used in our frontier models are as follows;

Y_i represents the quantity of cotton output in kg's

x_{1i} represents the total amount of land in acres on which cotton is grown

x_{2i} represents the total amount of labour hours

x_{3i} represents the total amount of fertiliser in kg's

x_{4i} represents the total amount of seed in kg's

x_{5i} represents the total number of irrigations from canal and tubewell (multiplied by cropped area)

x_{6i} represents the total number of sprays (multiplied by cropped area)

x_{7i} represents the mechanical expenditure in rupees

z_{1i} represents the proportion of crop area affected by the attack of cotton virus;

z_{2i} represents the age of the farmer;

z_{3i} represents the years of schooling of the farmer;

z_{4i} represents the years of experience in farming for the farmer;

z_{5i} represents the total number of visits of extension workers to the farm and farmer visits to the extension office;

z_{6i} is dummy used for sowing time (if the cotton crop is sown intime then 1, otherwise zero);

z_{7i} represents the dummy variable for credit access (if the farmer got credit then 1, otherwise zero);

z_{8i} is the dummy used for other source of income (if the farmer is getting income from other sources then 1, otherwise zero);

z_{9i} is the dummy for ownership tractor, (if the farmer owns the tractor then 1, otherwise zero)

z_{10i} is the dummy used to distinguish landowner and tenants (if the farmer owns the land then 1 otherwise zero).

Summary statistics for all of the variables included in the empirical model are reported in Table 1. The mean values of most variables are similar across the four districts. Rahim Yar Khan district has the lowest incidence of virus attack hence it also has the highest yield. From all the four districts, only 37 per cent farms were virus free. The average age of farmer and years of formal schooling is almost same in the study area. Farming experience and extension visits are also not different in all districts. From the dummy variables we observe that 90 per cent farms are sowing cotton in time, 68 per cent farmers don't have access to credit and 39 per cent farmers have another source of income, like a small business or some type of government service (such as being school teachers, field assistants or a retired army person). Almost 50 per cent farms have their own tractors and 90 per cent farmers in the current study own their land.

Table 1 Summary Statistics for Cotton Farmers Survey from the Punjab Province

Variables Districts	Sample Mean	Sample Standard Deviation	Minimum Value	Maximum Value
Output (kilograms)				
Arifwala	6226.71	9409.16	200	50840
Bahawalpur	9025.2	9353.43	500	43990
Multan	9340.27	12293.44	160	61000
Rahim Yar Khan	15297.14	16050.34	560	118560
Land (acres)				
Arifwala	13.33	14.26	2	80
Bahawalpur	20.2	17.10	2.5	85
Multan	21.14	22.52	2	120
Rahim Yar Khan	17.22	16.62	2	102
Labour (hours)				
Arifwala	668.59	750.51	52	4600
Bahawalpur	763.52	554.97	72.5	1983.5
Multan	749.39	744.60	59	3540
Rahim Yar Khan	528.22	537.69	42	3264
Fertiliser (kilograms)				
Arifwala	1258.25	1543.52	140	9400
Bahawalpur	1917.84	1744.28	172.5	9095
Multan	1902.53	2315.05	92	12120
Rahim Yar Khan	1962.06	2179.69	156	14076
Seed (kilograms)				
Arifwala	61.79	69.84	3	375
Bahawalpur	151.28	149.32	16	850
Multan	143.23	158.37	8	800
Rahim Yar Khan	133.75	138.42	10	918
Irrigation (total number of canal and tubewell irrigations)				
Arifwala	89.89	97.22	10	560
Bahawalpur	153.03	164.88	15	1020
Multan	163.65	178.88	12	800
Rahim Yar Khan	117.84	126.55	8	714
Spray (number)				
Arifwala	85.01	99.48	10	560
Bahawalpur	120.85	109.65	12.5	510
Multan	162.60	182.25	8	960
Rahim Yar Khan	98.36	106.83	8	612
Mechanical Expenditure (Rupees)				
Arifwala	5141.51	6006.73	640	36000
Bahawalpur	5126.87	5218.57	640	26640
Multan	6254.24	10935.54	220	41340
Rahim Yar Khan	4162.34	7440.14	320	40960
Cotton virus (proportionate attack)				
Arifwala	0.71	0.42	0	1
Bahawalpur	0.65	0.44	0	1
Multan	0.70	0.40	0	1
Rahim Yar Khan	0.11	0.29	0	1
Age of the farmer (Years)				
Arifwala	43.89	13.72	18	70
Bahawalpur	40.70	12.93	18	65
Multan	39.01	11.56	20	65
Rahim Yar Khan	41.78	13.79	17	75

(continued)

Education (School years)				
Arifwala	6.03	4.80	0	14
Bahawalpur	5.22	4.92	0	16
Multan	6.89	4.70	0	16
Rahim Yar Khan	6.71	4.51	0	16
Farming Experience (years)				
Arifwala	22.74	14.74	3	55
Bahawalpur	21.33	13.38	0	50
Multan	19.60	12.33	2	50
Rahim Yar Khan	22.25	13.03	4	60
Extension visits (number)				
Arifwala	5.20	5.41	0	22
Bahawalpur	4.10	4.47	0	21
Multan	6.85	7.03	0	35
Rahim Yar Khan	5.09	5.52	0	18
Intime (dummy)				
Arifwala	0.91	0.29	0	1
Bahawalpur	0.88	0.33	0	1
Multan	0.90	0.30	0	1
Rahim Yar Khan	0.87	0.34	0	1
Credit (dummy)				
Arifwala	0.18	0.39	0	1
Bahawalpur	0.37	0.49	0	1
Multan	0.34	0.48	0	1
Rahim Yar Khan	0.39	0.49	0	1
Other source of income (dummy)				
Arifwala	0.29	0.46	0	1
Bahawalpur	0.30	0.46	0	1
Multan	0.52	0.50	0	1
Rahim Yar Khan	0.45	0.50	0	1
Own tractor (dummy)				
Arifwala	0.42	0.50	0	1
Bahawalpur	0.60	0.49	0	1
Multan	0.48	0.50	0	1
Rahim Yar Khan	0.56	0.50	0	1
Tenants (dummy)				
Arifwala	0.95	0.22	0	1
Bahawalpur	0.86	0.35	0	1
Multan	0.99	0.12	0	1
Rahim Yar Khan	0.91	0.29	0	1

4. Empirical Results

Many efficiency studies employ the Cobb-Douglas (CD) functional form when estimating parametric frontiers. The CD, however is a simple functional form, which assumes unitary elasticities of substitution and fixed scale economies across all firm sizes. In this study we estimate both the CD and the (more flexible) translog forms. Statistical tests are used to choose between the two forms.

The Cobb-Douglas production frontier is defined as:

$$\ln Y_i = \beta_0 + \sum_{i=1}^{7} \beta_i \ln x_i + V_i - U_i \qquad i = 1,2,\ldots.N$$

where *i* denotes the *i-th* farm in the sample, *y* is output and the *x's* are input variables, as defined in the previous section. The V_i*'s* and U_i*'s* are the random variables also defined in the previous section.

The translog production frontier is defined as:

$$\ln Y = \beta_0 + \sum_{j=1}^{7} \beta_j \ln x_{ij} + \tfrac{1}{2}\sum_{j=1}^{7}\sum_{k=1}^{7} \beta_{kj} \ln x_{ik} \ln x_{ik} + V_i - U_i\,, \qquad i= 1,\ldots.N,$$

where all notation is as described previously.

Statistical Tests

Likelihood ratio tests were used to select the preferred functional forms. The likelihood-ratio test uses the following calculation:

$$\lambda = -2\{\log[L(H_0) - L(H_1)]\},$$

where $L(H_0)$ and $L(H_1)$ are the likelihood function values under the null and alternative hypotheses, respectively. The λ-statistic has asymptotic chi-square distribution, with degrees of freedom equal to the difference between the numbers of parameters of H_0 and H_1. Likelihood ratio tests were performed to test various hypotheses. The results of these tests are listed in the Table 2. All statistical tests described in this paper are at the five per cent level.

Table 2 Generalised likelihood-ratio tests of hypotheses for parameters of SFPF for cotton farmers in Pakistan

No	Null Hypotheses Districts	λ	Critical Value (χ^2)	Decision
Functional Form				
1	$\underline{H_0 : \beta_7\text{-}\beta_{35}=0}$			
	Arifwala	90.28	41.3	Reject H_0
	Bahawalpur	65.76	41.3	Reject H_0
	Multan	48.30	41.3	Reject H_0
	Rahim Yar Khan	71.66	41.3	Reject H_0
Testing for variance parameters and inefficiency effects variables				
2	$\underline{H_0 : \gamma=\delta_0 =\ldots\delta_{10}=0}$			
	Arifwala	119.20	17.67[a]	Reject H_0
	Bahawalpur	53.40	17.67	Reject H_0
	Multan	81.20	17.67	Reject H_0
	Rahim Yar Khan	57.79	17.67	Reject H_0
3	$\underline{H_0 : \delta_1 =\delta_2=\ldots.\delta_{10}=0}$			
	Arifwala	98.22	18.31	Reject H_0
	Bahawalpur	41.60	18.31	Reject H_0
	Multan	81.92	18.31	Reject H_0
	Rahim Yar Khan	38.76	18.31	Reject H_0

a This critical value is taken from Table 1 of Kodde and Palm (1986).

The 1st hypothesis listed in Table 2, that the Cobb-Douglas frontier is an adequate representation for cotton farmers, is rejected for all four districts. This suggests that the translog is preferred. The 2nd hypothesis test specifies that farms are operating on the technically efficient frontier. It implies that no inefficiency is present in production and that the traditional average response function, in which all farms are fully efficient, is an adequate representation of the data. This null hypothesis is also rejected in all four districts. The final test is concerned with determining whether the farm-specific variables *(z's)* included in the inefficiency effects model have an effect on the level of technical inefficiency. The null hypothesis is rejected confirming that the effect of these variables on technical inefficiency is statistically significant.

The maximum-likelihood estimates for the parameters in the translog stochastic frontier production functions for the Pakistani cotton farmers are presented in Table 2. The input and output data was mean-corrected prior to estimation. Hence, the first order β-coefficients in the translog model are interpreted as partial output elasticity's. The asymptotic t-ratios for the MLE estimators are presented below the corresponding estimates. Economic theory tells us that the estimated production elasticities should be positive. The results provide a mixture of positive and negative signs and the first order β-coefficients across the four districts. We do observe that only two of the negative coefficients are significantly different from zero (land and mechanical expenditure in the Multan and Rahim Yar Khan districts, respectively). Hence the number of negative coefficients may be more due to data problems than due to other serious problems. The spray variable is found to have the most negative coefficients. It is negative in three of the four districts. This was unexpected given the importance of pesticides to cotton production. However, there has been some opinions among the farmers that extra spraying can help reduce the impact of cotton virus tend to spray more than the others (well above recommended rates). Thus, the spray variable may be acting as s proxy for the severity of the virus. This could explain the negative signs in this case. The signs on the δ-coefficients are of particular interest. One would expect that all δ's, with the exception of δ_1 (associated with the virus), should have negative signs (indicating that the variables reduce inefficiency). That is, more education and experience, etc should reduce inefficiency.

The signs on the virus coefficient are all positive as expected. These coefficients also have very high t-ratios, indicating that virus attack has a large influence upon efficiency levels. The majority of the other δ-coefficients have mixed signs and low t-ratios. It thus appears that age, education, experience, extension advice, sowing on time, access to credit, off-farm interests, ownership of a tractor and land ownership all have little influence upon efficiency levels. It is, however, interesting to note that the strongest t-ratios among their variables is for tractor ownership, where all t-ratios are greater than one. However, the signs are all positive, which is contrary to expectations. We expected that tractor ownership would ensure that the farmer could plant, sow, spray, etc at the optimal time and hence appear more efficient. However, these results suggest that perhaps the farmer may be spending a lot of time using his tractor on other farms and hence neglecting his own crops to some degrees.

Table 3 MLE (Translog) for Parameters of the SFPF and Inefficiency Models for cotton Farmers in Pakistani Districts of the Punjab Province

Variables	Parameters	Arifwala	Bahawalpur	Multan	Rahim Yar Khan
Constant	β_0	0.67	0.70	-0.22	0.28
		(24.24)	(11.23)	(-1.56)	(6.45)
Ln(Land)	β_1	0.45	-1.30	-0.92	0.18
		(2.87)	(-2.76)	(-2.72)	(0.73)
Ln(Labour)	β_2	0.29	-0.09	1.16	-0.05
		(3.25)	(-0.62)	(4.34)	(-0.63)
Ln(Fertiliser)	β_3	0.47	0.32	0.85	0.28
		(7.09)	(2.79)	(4.92)	(3.20)
Ln(Seed)	β_4	-0.02	-0.32	0.48	0.46
		(-0.87)	(-1.87)	(2.54)	(3.90)
Ln(Irrigation)	β_5	-0.02	1.11	-0.38	0.13
		(-0.17)	(5.17)	(-1.51)	(0.94)
Ln(Spray)	β_6	-0.07	0.71	-0.19	-0.09
		(-0.57)	(4.18)	(-0.95)	(1.41)
Ln(M.Expd)	β_7	0.21	0.64	-0.05	-0.08
		(4.48)	(9.87)	(-0.90)	(-2.84)
$Ln(Land)^2$	β_{11}	-3.60	-15.46	2.12	1.88
		(-4.64)	(-20.16)	(0.96)	(1.67)
$Ln(Labour)^2$	β_{22}	-1.92	-3.26	0.88	0.06
		(-11.41)	(-3.95)	(1.52)	(0.19)
$Ln(Fertiliser)^2$	β_{33}	-2.61	0.24	-0.17	0.04
		(-7.33)	(1.14)	(-0.37)	(0.55)
$Ln(Seed)^2$	β_{44}	-0.21	-2.68	0.56	-1.62
		(-5.35)	(-5.93)	(4.68)	(-5.34)
$Ln(Irrigation)^2$	β_{55}	-1.20	-0.70	1.77	-0.21
		(2.59)	(-1.25)	(2.35)	(-1.06)
$Ln(Spray)^2$	β_{66}	0.22	-0.80	2.15	0.20
		(0.74)	(-1.60)	(4.06)	(1.35)
$Ln(M.Expd)^2$	β_{77}	-0.43	-0.60	0.11	-0.01
		(-6.37)	(-5.58)	(1.68)	(-0.34)
Ln(Ld)Ln(Lb)	β_{12}	2.50	7.81	1.64	-0.72
		(3.69)	(5.65)	(1.44)	(-0.58)
Ln(La)Ln(F)	β_{13}	4.92	0.38	0.87	0.11
		(7.79)	(0.48)	(0.78)	(0.12)
Ln(La)Ln(Sd)	β_{14}	-0.17	9.23	2.45	0.43
		(-1.05)	(10.04)	(2.00)	(0.39)
Ln(Ld)Ln(Irri)	β_{15}	2.65	9.43	-2.38	-1.53
		(4.41)	(8.93)	(-1.35)	(-1.90)
Ln(Ld)Ln(Spr)	β_{16}	-1.87	3.8	-5.97	-0.69
		(-2.08)	(3.97)	(4.43)	(-0.88)
Ln(Ld)	β_{17}	-1.02	-0.61	-0.80	-0.45
Ln(M.Expd)		(-3.39)	(-0.89)	(-2.36)	(-2.31)
Ln(Lb)Ln (F)	β_{23}	0.73	-0.52	0.42	-0.18
		(1.65)	(-0.82)	(0.44)	(-0.56)
Ln(Lb)Ln(Sd)	β_{24}	0.53	-0.92	1.55	0.81
		(2.76)	(-1.20)	(1.51)	(1.31)
Ln(Lb)Ln(Irri)	β_{25}	0.52	-1.76	-3.65	-0.51
		(0.77)	(-2.81)	(-3.25)	(-1.71)
Ln(Lb)Ln(Spr)	β_{26}	-0.74	0.91	-0.41	0.56
		(-1.48)	(0.96)	(-0.48)	(2.72)

(continued)

Ln(Lb) Ln(M.Expd)	β_{27}	0.16 (1.73)	0.65 (2.41)	-0.70 (-2.35)	0.04 (0.37)
Ln(F)Ln(Sd)	β_{34}	0.37 (2.74)	0.57 (1.14)	-2.29 (-2.76)	-0.23 (-0.49)
Ln(F)Ln(Irri)	β_{35}	-2.82 (-4.46)	-0.61 (-0.83)	-1.50 (-2.59)	0.21 (0.55)
Ln(F)Ln(Spr)	β_{36}	0.50 (0.99)	-0.14 (-0.20)	2.11 (2.78)	-0.13 (-0.28)
Ln(F) Ln(M.Expd)	β_{37}	1.13 (18.41)	0.03 (0.11)	0.43 (2.47)	0.30 (4.00)
Ln(Sd)Ln(Irri)	β_{45}	-0.36 (-1.67)	-2.79 (-4.30)	1.47 (1.75)	1.70 (3.38)
Ln(Sd)Ln(Spr)	β_{46}	0.45 (2.20)	-0.76 (-1.13)	-3.53 (-4.14)	-0.57 (-1.05)
Ln(Sd) Ln(M.Expd)	β_{47}	-0.26 (-6.94)	-0.33 (-0.97)	0.05 (0.26)	0.43 (6.37)
Ln(Irri)Ln(Spr)	β_{56}	1.83 (2.94)	-2.58 (-3.79)	2.11 (2.94)	0.23 (0.90)
Ln(Irri) Ln(M.Expd)	β_{57}	1.09 (3.71)	0.82 (2.58)	1.63 (0.79)	-0.16 (-1.51)
Ln(Spr) Ln(M.Expd)	β_{67}	-0.50 (-1.49)	0.47 (1.24)	0.68 (2.55)	-0.008 (-0.07)
Constant	δ_0	-3.03 (-7.01)	0.65 (-1.51)	1.09 (3.13)	-0.67 (-1.79)
CLCV	δ_1	1.70 (9.86)	0.31 (2.82)	0.99 (9.21)	0.74 (3.84)
Age	δ_2	0.001 (0.08)	0.02 (-0.05)	-0.0005 (-0.08)	0.02 (1.45)
Education	δ_3	-0.04 (-2.02)	0.02 (0.29)	-0.006 (-0.61)	0.007 (0.43)
F.Exp	δ_4	0.01 (1.32)	0.02 (-1.21)	-0.005 (-0.97)	0.002 (0.15)
Ext (V)	δ_5	0.02 (1.45)	0.02 (0.74)	-0.008 (-1.16)	0.01 (1.40)
In.Time	D_1	0.15 (0.71)	0.29 (0.72)	-0.30 (-2.19)	-0.04 (-0.19)
Credit	D_2	0.26 (1.31)	0.19 (1.21)	-0.22 (-2.28)	0.21 (1.54)
Other income	D_3	-0.05 (-0.34)	0.23 (-0.18)	-0.18 (-2.25)	0.24 (1.59)
Trac.Own	D_4	0.14 (1.05)	0.27 (0.49)	0.28 (2.85)	0.33 (2.43)
Tenants	D_5	0.12 (3.25)	0.26 (0.54)	-1.06 (-3.61)	-0.95 (-4.53)
Sigma Sq	$\sigma_s^2 = \sigma^2 + \sigma_v^2$	0.07 (5.15)	0.11 (4.16)	0.05 (5.71)	0.01 (5.17)
Gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.99 (15275.86)	0.99 (206.21)	0.000009 (0.72)	0.99 (822.69)
Loglikelihood Function		58.34	31.14	8.11	45.35
Mean Efficiency		76 %	78%	77%	83%

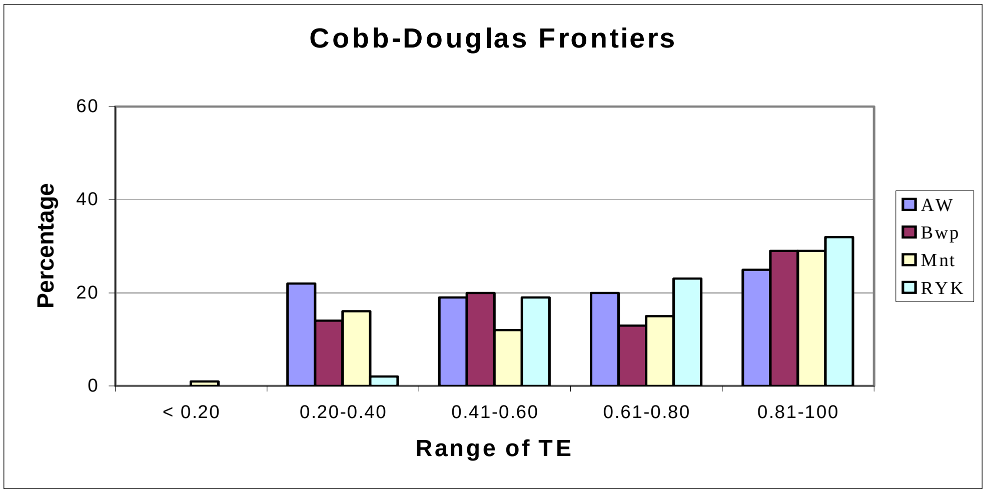
The mean technical efficiency scores for the four districts under the alternative functional forms are reported in the Table 4. The mean technical efficiency is highest in Rahim Yar Khan. This is as expected, gives the lower impact of the virus in this district.

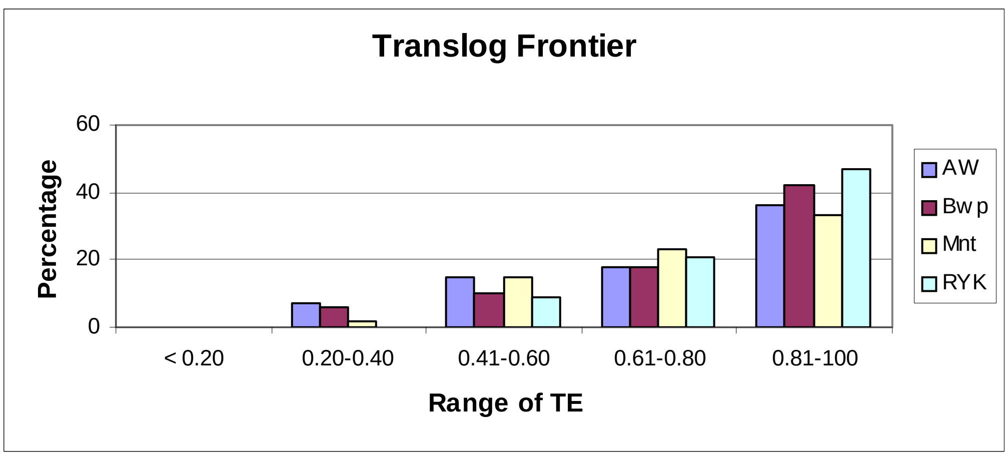
Table 4 Mean efficiency scores of cotton farms under alternative functional forms, period 1996-97

Districts	Translog	Cobb-Douglas
Arifwala	0.76	0.58
Bahawalpur	0.78	0.66
Multan	0.77	0.65
Rahim Yar Khan	0.83	0.73

In all districts the mean technical efficiency of the translog is higher than that of the Cobb-Douglas. This is as one would expect, given the restrictive nature of the Cobb-Douglas form. The technical efficiencies of the cotton farms under different districts for the technical inefficiency effects were predicted tables of these values are not presented because of the large number of values in all districts. Histograms of predicted technical efficiencies are graphed in Figure for the two different functional forms. Figure 1 shows the frequencies of the predicted technical efficiencies in different districts are not similar across functional forms. The more flexible translog function provides a distribution, which is shaped like a half-normal distribution while the Cobb-Douglas form provides a more block shaped distribution. These results suggest that the selection of functional forms does effect the levels and distributions of farm efficiency. It is therefore implied that careful selection of the functional form is important.

Figure 1 Effects of alternative functional forms on efficiency scores of Cotton farms





5. Summary and Conclusions

In this paper, SFPF's are estimated for cotton farms in four districts of the Punjab province using cross sectional data for 1996-97. Given the specifications of the translog model we found that technical inefficiency of production by individual farmers are present in all districts. Mean technical efficiencies ranged from 76% to 83% across the four districts, indicating significant room for improvement. The largest score 83% was found in Rahim Yar Khan district where the incidence of virus attack was lowest (11%). The virus attack variable was found to be the most significant variable in explaining differences in technical efficiencies among farms in the four districts. The other firm-specific variables considered, including age, education and extension advice, were not significant explanation of inefficiency in most districts. Technical efficiencies were calculated for both Cobb-Douglas and translog functional forms. Likelihood ratio tests indicated that the translog was the preferred form. The mean technical efficiencies and efficiency distribution were observe to differ markedly between the two functional forms. This indicates that one must be careful in the selection of a functional form when seeking measures of technical efficiency.

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