THE DETERMINANTS OF TECHNICAL EFFICIENCY OF COTTON FARMERS IN THE SOUTHERN PUNJAB (PAKISTAN)

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Abstract

The paper analyses the technical efficiency of cotton farmers in southern Punjab of Pakistan. The samples of 100 cotton growing respondent randomly selected from different villages of Rahim Yar Khan District. Data collected through questionnaires for study. The Cobb-Douglas production function found to be an adequate representation of data. The technical inefficiency effect found to present. The mean predicted technical efficiency of cotton farmers was0.87 which to be ranging to 0.17 to 0.97. The result of the frontier model points out that cotton production could increased through increasing cotton area, pesticides, irrigation, cultivation, labor and fertilizer use. The technical inefficiency model explains that inefficiency of farmers could reduce through the increase in education increasing contact to agriculture expert's own tubewell and sowing timely.

Key Words: Technical efficiency, cotton, stochastic frontier function, Punjab, Pakistan

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1- Introduction

The agriculture sector continues to be an essential component of Pakistan's economy. It currently contributes 21 percent to GDP. Agriculture generates productivity employment opportunities for the 45 percent of country's labor force and the 60 percent of the rural population depends upon this sector for its livelihood. It has a vital role in ensuring food security generating overall economic growth reducing poverty and the transforming towards industrialization (Government of Pakistan 2011-12).

During 2011-12, the overall performance of agriculture sector exhibited a growth of 3.1 percent mainly due to growth in agriculture related subsectors, except minor crops. Major crops, such as wheat cotton rice and sugarcane accounts for 91 percent of the value added in the major crops. The value added in major crops accounts for 32 percent of the value added in agriculture. Thus, four major crops (wheat rice cotton and sugarcane) on average contribute 29 percent to the value added in overall agriculture and 6 percent in GDP. The minor crops accounts for 10.1 percent of the value added in overall agriculture (GOP 2011-12).

Cotton is an important cash crop, which significantly contributes to the national economy by providing the raw material to the textile industry such as cotton lint an export item. It accounts for 7.8 percent of value added in agriculture and 1.6 percent of GDP. During 2011-12, the crop was cultivated on an area of 2835 thousands hectares, 5.4 percent more than the last year (2689 thousands hectares). The production is reported at 13.6 million bales during the period (July-March) 2011-12, higher by 18.6 percent over the last year's production, which was 11.5 million bales (Pakistan Bureau of Statistics 2011-12).

China India USA Pakistan Brazil and Uzbekistan are six major cotton-producing countries of world. These countries produce more than 80 percent of total world cotton production. Pakistan places 4th position in cotton production after China India and USA with the share of 8.76 percent of total world production. Pakistan is third major consumer of cotton after China and India with the share of 9.72 percent of total world consumption (Pakistan Central Cotton Committee 2011-12).

Despite major cotton, producing county of world the yield of cotton crop in Pakistan is still low as comparative to others major cotton producing countries. Cotton yield per hectares of major cotton producing countries is China1326 (kg) USA886 (kg) Brazil1353 (kg), Australia1839 (kg)

Uzbekistan1474 (kg) India473 (kg) and Pakistan 721(kg) (United States Department of Agriculture 2011-12).

Cotton is a prominent crop of Pakistan while unsatisfactory condition of crop production and yield is serious issue for concerning authorities. Agriculture growth is not keeping up with increasing population of country. In such conditions, population requirement cannot meet this current productivity of agriculture crops. The yield of the Pakistan's crop is lower than world agrarian countries. Pakistani farmers are producing lower than potential level of production, which is point of serious concern.

There are only few studies in cotton crop like Hussain (1999) Battese and Hassan (1999) Abedullah (2006) and Rehman (2000). According to Hussain (1999), lower Yield in Pakistan is mainly due to psychological agronomics socio-economic political factors and poor resource management. Poor management is more conspicuous of all factors in particularly input use. Ali and Choudhry (1990) Efficiency is a very important factor for productivity growth especially for developing agriculture economies where they have limited resources and less opportunity to adopt new and mechanical technologies.

The discussion above which to be explains the source to how to increase productivity of cotton crop and these improvements can applied to increase productivity. The present study is oriented toward the goal of achieving higher productivity by improving technical efficiency of cotton farmers and overcoming inefficiency measures. The main objective of study is to estimate technical efficiency of cotton farmers in southern Punjab of Pakistan using the stochastic production frontier approach.

The rest of the paper proceeds as follow, section two briefly discuss the methodology and data collection procedure section three discuss the results of the study while the last and fourth section contains on conclusion and suggestions.

2- Methodology and Data collection procedure

2.1 Methodology

Technical efficiency refers to the ability of producer to avoid the waste of inputs by producing as much output as the inputs at his disposal permits under the current state of technology (Farrell, 1957). In the current scenario, different methodologies have adopted for the estimation of technical efficiency while the two are most prominent parametric approach (stochastic production frontier approach) and non-parametric approach (Data Envelopment Analysis). A problem with DEA approach is that no account taken of the measurement error and others sources of the statistical noise all deviation from the frontiers assumed the result of technical inefficiency. Solution to the problem is to introduce another random variable representing the statistical noise resulting frontier is known stochastic production frontier (Coelli, Ch, 9 2005).

The stochastic frontiers production function method adopted to estimate the technical efficiency of cotton farmers in the study area. Aigner et al (1977), Battese and Corra (1977), Meeusen, and van den Broeck (1977) proposed a SFA parametric approach a regression-based method incorporates a composed error term. Following their specifications, the stochastic production frontier can written as,

$$yi = F(xi, \beta\square)\, e^{\square} \qquad i = 1,2\ldots..N \qquad (1)$$

Where yi is the output of cotton for ith farms where the xi is the vector of k inputs, β is vector of k unknown parameters and ε□ is an error term. The stochastic production frontier also called composed error model because it postulates that all the error term ε□ decomposed into two components: a stochastic random error component (random shocks) and a technical inefficiency component as follow

$$\varepsilon\square = Vi - Ui \qquad (2)$$

The vi is a symmetrical two sided normally distributed random error that captures the stochastic effect outside the farmers control (weather, luck) measurement error and others statistical noise. It is assumed to be independently and identically distributed N (0, σ²□). Thus vi allows production function vary across the farmer the over time for the same farm and therefore the production frontier is stochastic. The term ui is a one sided (ui≥0) efficiency component that captures the technical inefficiency of the ith farmer. This one sided error term can follow different distributions such as truncated-normal, half-normal, exponential and gamma (Aigner et al 1977, Meeusen and Broeck 1977). In this paper, it assumed Ui follows as half normal distribution N (0, σ□²) as typically done in the applied stochastic frontier literature. The two error components (v and u) also assumed independent of each other's. The variance parameter of the model are parameterized

$$\sigma^2 \mathrm{Ş} = \sigma^2\square + \sigma\square^2 : \Upsilon = \sigma\square^2/\sigma^2\mathrm{Ş} \qquad 0 \leq \Upsilon \leq 1 \qquad (3)$$

The parameter ϒ lies between 0 and 1. The maximum likelihood estimation of equation (1) provides consistent estimator for β, ϒ and σ²Ş parameters. Where, σ²Ş explains total variation in dependent variable due to technical inefficiency (σ□²), and random shocks (σ²□) altogether.

The function determining the inefficiency effect defined in its general form as a linear function of socio-economic and management factor:

Ui = F (□i) (4)

More detail of dependent and independent variable explained in the empirical model.

2.2 Empirical Model

The empirical specification of stochastic frontier production function given as below:

Ln Y□ = βo + ∑□ □ □ □ β□ +ln X□ +v□-u□ (5)

i = 1, 2…...m

X represents the vector of k inputs used in the cotton production while the βo, βi are unknown parameter to be estimate and u□ and the v□ are the random variables explained in the previous section. The traditional explanatory variables used in the study as used in the previous cotton efficiency studies. Following is the description of the variables used in the model.

Such a method is appropriate because agriculture production in general exhibits shocks hence there is need to separate the influence the stochastic variables(random shocks and measurement errors) from resulting estimates of technical inefficiency(Battese,1992). For the study Cobb-Douglas, production function used to fit stochastic production frontier.

Yi = Explains the total cotton production (in maunds) of the farmer

X1 = Total area of cotton crop production (in acres)

X2 = Quantity of Seed (in kg) per acre which is used to sown.

X3 = Pure nitrogen applied to the unit area (kg) per acre

X4 = Pure phosphorus applied to unit area (kg) per acre.

X5 = Cost of pesticides used against germs and weedics in (Rs) per acre.

X6 = Number of irrigation per acre (canals and tube well)

X7 = Number of family labor adult worked at farm operations

X8 = Number of cultivation per acre times area of cotton grown.

The β,s = 0,1,2,3,4,5,6,7,……are unknown parameters of the production function and the Vs are random error associated with measurement error in production of cotton where Vs are assumed to be independent and identically distributed N(0,ŏv) random variables. We have the variables in the study like the total area of cotton crop in acres, seed used in sowing kg, fertilizers nitrogen and phosphorus are separately included as Shafiq and Rehman (2000) and Gul (2009) uses in their studies.

Technical inefficiency could be estimate by subtracting technical efficiency from one. The function determining the technical inefficiency effect is defined in general form as a linear function of as discussed below

U□ = Ω0 +∑□ □□ □ Ω□ □i (6)

Where the Ui are non negative random variables associated with the technical inefficiency of production of farmer assumed to be independently disturbed such that the technical inefficiency effect for the i-th farmer growing the t-th crop to obtained by truncation(at zero) of the normal distribution with mean Ui and variance such that

Ui = Non-negative random variable explains the technical inefficiency of the production farmers.

□1i = Age of farmer in years which are operating the farm

□2i = Education or schooling years of farmer.

□3i = Family size of the farmer.

□4i = Operational farm area in acres.

□5i = Dummy variable (1) if received Credit from bank or dealer otherwise (0).

□6i = Dummy variable showing tenancy status owner (1) other (0).

□7i = Dummy variable tube well own (1) otherwise (0).

□8i = water shortage in percentage.

□9i = Dummy variable (1) if indicating the contact to the agriculture extension otherwise 0)

□10i= Dummy variable sowing timely indicating (1) if late or earlier indicating (0).

It assumed some farmers are producing on the frontiers while others do not produce on the frontier. Thus, the need arises for finding out factors causing technical inefficiency. The technical inefficiency model developed for this study to concentrate on this issue.

Various software packages exist to estimate maximum likelihood estimates parameters of the stochastic production function describe in equation (5). We employed Frontier 4.1 developed by

Coelli (1994). However, it should be noted here that technical efficiency model and inefficiency effect model is not estimated step by step as discussed above rather study employed Frontier 4.1 software which can estimate the coefficient of production function and inefficiency effect model altogether.

2.3 Data collection procedure

Analysis carried out by using the primary data of the 100 farmers of cotton crop from the district Rahim Yar Khan of Punjab Pakistan. Four villages were randomly selected and 25 cotton producer of the each village. A well-structured and field pre-tested comprehensive interviewing schedule used for the collection of the data in detailed information in various aspects of cotton crop for the year 2010-11.

Table-1 Basic Statistics on Farm Basis

Efficiency Level				
	Mean Value	**Standard error**	**Minimum Value**	**Maximum value**
Efficiency (%)	0.87896	0.11201	0.17408	0.97399
Cotton production(Munds)	393.96	992.236	5	9350
Seed (kg)	195.09	383.51	5	3400
NitrognFertilizer(kg)	5896.513	13019.93	156.25	116875
Phosphorus Fertilizer(kg)	1015.8375	2366.8292	6.25	21250
Pesticides cost(Rs)	94357.5	267016.4473	1250	2550000
Irrigation (No)	388.7	610.4	10	4250
Family Workers (No)	4.04	1.632	2	9
Cultivation (No)	115.76	315.67	2.5	2975
Age of farmer (years)	40.55	10.88	20	85
Education(year of schooling)	4.45	3.488	0	14
Family Size (no)	7.98	4.539	3	31
Farm Area (Acres)	29.59	46.11	3	425
Credit (dummy)	0.17	0.378	0	1
Tenancy (dummy)	0.56	0.499	0	1
Tube well own(dummy)	0.61	0.490	0	1
Water shortage (%)	36.09	14.646	10	75
Contact Agric Extension(dummy)	0.14	0.348	0	1

Sowing Timely(dummy)	0.17	0.377	0	1

Table-2 Maximum likelihood estimates for Parameters of Stochastic Frontier Production Function and Inefficiency Model for Cotton Farmers in Southern Punjab Pakistan

Variable	Parameter	Standard Error	T-value
β	0.327	0.838	-0.390
Ln Cotton area(Acres)	0.977	0.418	2.332
Ln Seed(kg)	-0.139	0.966	1.446
LnNitrognFertilizer(kg)	0.605	0.974	6.210
LnPhosphorus Fertilizer(kg)	0.191	0.171	1.116
LnPesticides cost(Rs)	0.280	0.857	3.273
Ln Irrigation (No)	0.410	0.642	6.393
Ln Family Workers (No)	0.114	0.983	1.162
Ln Cultivation (No)	0.223	0.115	1.945
Inefficiency Model			
δ	-0.437	0.109	-0.401
Age of farmer (years)	0.370	0.108	0.341
Education (year of schooling)	-0.337	0.640	-0.527
Family Size (no)	-0.473	0.315	-0.150
Farm Area (Acres)	0.364	0.287	0.126
Credit (dummy)	-0.829	0.766	-0.108
Tenancy (dummy)	0.137	0.481	0.285
Tube well own(dummy)	-0.512	0.332	-0.152
Water shortage (%)	0.453	0.121	0.373
Contact Agric Extension(dummy)	-0.208	0.400	-0.520
Sowing Timely(dummy)	-0.829	0.766	-0.108
Parameters of Variance			
$\sigma^{2\ s}$	0.185	0.285	0.647
ϒ	0.906	0.328	0.275
Log-Likelihood function	26.50		

3- Results and Discussions

The technical efficiency and factors influencing technical efficiency model examined by fitting a frontier production function model including the explanatory factors of technical inefficiency. The results obtained from the model estimation explained in the table 2.

The value of coefficient of cropped area of the cotton production to be 0.977 which to be explains that one percent increase in cotton areas will increase the cotton production 0.977 percent where the t-ratio 2.332 which is statically significant at five percent level of significance. The results are in line with the studies of Hussain (1999) Battese and Hassan (1999) Battese and Broca (1997) Coelli and Battese (1996) Parikh et al (1995) Battese et al (1993) and Ali and Choudhry (1990) and Hassan (2004). Coefficient of seed to be negative sign -0.139 that points out one percent increase in seed usage would decrease in cotton yield -0.139 percent. The t-ratio to be the 1.446 which to be significant at ten percent the finding of study to be in line with previous studies Battese and Hassan (1999) Hassan (2004) and Bakhash(2007).

Two fertilizer categories pure nitrogen and pure phosphorus fertilizers are consider individually. The Coefficient nitrogen fertilizer that is 0.605 which explains that one percent increase in the nitrogen fertilizer use increases cotton production 0.605. The use of the phosphorus fertilizer with the coefficient of 0.191 explains that one percent increase in the phosphorus use increase in the cotton production 0.191 percent. Nitrogen fertilizer with the t-ratio of 6.210 that to be significant at one percent level of significance. Phosphorus fertilizer with the t-ratio of 1.116 that to be statically significance at ten percent level of significance. Results of the fertilizer variables are in line with the study of the Hassan (2004) Hussain (1999) and Battese, Malik and Broca (1993).

Plant protection measures (Rs per acres) have positive sign of the coefficient, which is 0.280 according to expectations, which is to be explaining that increase in the one percent in the expenditures of plant protection measures will increase cotton production 0.280 percent. The calculated t-value to be 3.273, which is statically significant at five percent level of significance the results are in line with the studies of the Battese and Hassan (1999), Hassan (2004).

The variable of irrigation which to be coefficient of 0.410 which points out that one percent increase in the irrigation will increase in cotton production 0.410 percent while the calculated t-value to be 6.393 which is statically significant at one percent level significant. The results are in line with the studies of Hussain (1999) Ahmad (2001) and Hassan (2004).

The coefficient of labor is to be 0.114 which points out that increase in one more worker will increase in the cotton production 0.114 while the calculated t-value is to be 1.162 which to be explain the value is significant at ten percent level of significance. These elasticties are consistent with the studies of the Battese et al (1993) Hussain (1999) and Hassan (2004).

Coefficient of cultivation is to be the0.223, which explains that increase in the one ploughing will increase in cotton production 0.223 percent while the calculated t-value is to be 1.945, which is significant at ten percent and statically significant. The result is in line with Battese, Malik and Broca (1993) and Hassan (2004).

Technical inefficiency model explains the results. Age of the farmer with positive sign points out that aged farmers is more experienced than younger while they are more inefficient than young farmers are. Increase the technical inefficiency and decreases the technical efficiency because they are hesitated to adopting new mechanizations and follow traditional methods the results are in line with the studies of the Parikh et al (1995) and Bakhsh (2007). The coefficient of the education with the negative sign explaining that education reduces the technical inefficiency so that literate farmers less inefficient than the illiterate farmers the result are consistent with the studies of the Hussain(1999) Ahmad(2001) coelli(1996) Battese et al(1993,1996) Rauf(1991) and Hassan(2004).

The variable of family size explaining with negative sign that large families reduces technical inefficiency cotton farming labor intensive crop due to complicated process such of the results consistent with the studies of the Kalirajan(1990), Parikh et al(1995) and Dhungana et al (2004). Farm area increases it increases the technical inefficiency due to administrative reasons so the results are in line with the studies of the Khan and Makki (1980), Burki, and Shah (1998). The coefficient of tenancy is a binary variable having positive sign that owners are less efficient than owners the reason lie that owners operates the large farms and it is difficult to manage large farms. Results are in line with the study of Bakhsh (2007).

The coefficient of dummy variable of tubewell with negative sign explains that owner tubewell reduces technical inefficiency as compared to those farmers, which have no tubewell the results to be consistent with the study of Hassan et al (2004). Water shortage have positive sign according to expectation explaining that water shortage to the cotton crop increases inefficiency of farmers. The results are consistent with the study of Ali and Flin (1989) and Hassan et al (2004).

Contact to agriculture extension having negative sign according to expectations. The farmer which have continuous contact to agriculture experts are less inefficient than those farmer which do not having contact with agriculture experts. Results are in line with the studies of the

Kumbhakar and Bhattacharya (1992), Bravo-Ureta and Evenson (1994), Parikh et al (1995), Bravo-Ureta and Pinherio (1997), Ahmad et al (1999) and Bakhash (2007).

The variable of sowing in time has sign according to expectation. Negative sign that timely sowing of seed of cotton reduces technical inefficiency so the farmers who sow seeds in time technical less inefficient those who sow seed late or early the results consistent with the studies of the Hassan (2004).

Table-3 Technical efficiencies of Sample Wheat Farmers Obtained Using the Cobb-Douglas Stochastic Frontier Production Function Model

Farmers Numbers	Technical Efficiency	Farmers Numbers	Technical Efficiency	Farmers Numbers	Technical Efficiency	Farmers Numbers	Technical Efficiency
1	0.49200	26	0.92694	51	0.85292	76	0.81975
2	0.89102	27	0.87703	52	0.51379	77	0.92779
3	0.75187	28	0.91459	53	0.94382	78	0.73214
4	0.85535	29	0.94109	54	0.91520	79	0.78405
5	0.97096	30	0.91031	55	0.95936	80	0.86440
6	0.96204	31	0.94763	56	0.89993	81	0.92638
7	0.89018	32	0.90021	57	0.95299	82	0.92289
8	0.85432	33	0.88199	58	0.92382	83	0.92636
9	0.83864	34	0.84424	59	0.90761	84	0.87707
10	0.89545	35	0.93687	60	0.94722	85	0.65766
11	0.91754	36	0.94888	61	0.94383	86	0.80983
12	0.93472	37	0.92556	62	0.90358	87	0.83043
13	0.93908	38	0.94882	63	0.87693	88	0.93079
14	0.92065	39	0.91657	64	0.81901	89	0.95804
15	0.90079	40	0.92710	65	0.93995	90	0.94485
16	0.84052	41	0.91500	66	0.87954	91	0.92939
17	0.91193	42	0.92780	67	0.77254	92	0.93360
18	0.60057	43	0.97175	68	0.81240	93	0.79322
19	0.95604	44	0.85913	69	0.91737	94	0.92419
20	0.92679	45	0.89789	70	0.86975	95	0.70709
21	0.93084	46	0.95987	71	0.92622	96	0.83680
22	0.94091	47	0.94355	72	0.82865	97	0.93603
23	0.97399	48	0.92666	73	0.87336	98	0.79769
24	0.96605	49	0.17408	74	0.93344	99	0.92908
25	0.94323	50	0.93012	75	0.87375	100	0.94645

Mean Technical Efficiency = 0.87896

Technical inefficiencies in the technical inefficiency model estimated with various variables. The predicted technical inefficiencies of individual farmers area to be 100 cotton farmers of the southern Punjab with the technical mean value maximum and minimum technical efficiency values to shown in the table. The number of observation is 100 and the mean technical efficiency is 0.75 and the highest level of technical efficiency 0.956 and lowest level of technical efficiency 0.176. The table explains the average loss due to the technical inefficiency 24% but the loss varies the 4% to the 82% among the sample farmers.

4- Conclusions and Suggestions

The results of study points out that the technical inefficiency prevails in cotton farming zone of the southern Punjab of Pakistan while the overcoming these inefficiencies the cotton production can be increased on the average of 24% through the current prevailing sources of cultivation. Study through the results indicates some of the policy suggestions, given below.

1. Increase in the size of cotton area increases the cotton production and the same way increase in the operational area of cultivation reduces the technical inefficiency of farmers. Increasing population in the rural and urban areas have reduced the operational areas of cultivation which negatively affected in cotton production so the cooperative farming must encouraged by the government institution of agriculture and encouraging steps provision of machinery and loan must be by the government to the farmers to utilize the barren land.
2. Agriculture inputs must be subsidized specifically the fertilizer (phosphorus) due to higher prices farmers uses less fertilizer than quantity, which negatively effects in cotton production. The results explains about that while the agriculture institution must convince the farmers through corner meeting print media to use pesticides according to recommendation of agriculture experts over usage of pesticides negatively affected cotton crop production.
3. Water shortage have the adverse effects on the cotton production and increases the technical inefficiency of the cotton farmers so the government must increase the water reserves and play vital role in provision of irrigated water throughout the year to the crop

areas.

4. Last one that Agriculture department can play pivot role in agriculture production and reducing the technical inefficiencies of the farmers through their close contact to the farmers the results in the study explains these that contact to agriculture experts have reduces the technical inefficiency of the farmers.

References

Abedullah, K. Bakhsh and B, Ahmad (2006) "Technical Efficiency and its Determinants in Potato production Evidence from Punjab, Pakistan" *The Lahore journal of Economics* vole 11-2 pp 1-22

Ahmad. M. (2001) Agriculture productivity growth Differential in Punjab, Pakistan A District Level Data" the Pakistan Development Review 40:1 1-25

Ahmad, M. M. Rafiq, and A. Ali (1999) an analysis of technical efficiency of rice farmers in Pakistani Punjab The Bangladesh Journal of Agriculture Economics, 22:79-86.

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.

Ali. M and J.C. Flinn (1989) Profit efficiency among Basmati Rice Producers in Pakistan Punjab: American Journal of Agriculture Economics 71, 303-10

Ali. M. M.A Choudhry (1990) "Inter-regional farm efficiency in Pakistan's Punjab: A production frontier function study, Journal of Agriculture economics 41, and 62-74.

Bakhsh, K (2007). An analysis of technical efficiency and profitability of growing potato ,carrot, radish and bitter gourd ;A case study of Pakistani Punjab , *Unpublished Ph.D thesis Dissertation. Department of farm* Management, *University of Agriculture* Faisalabad, Pakistan

Barki, A .A. and H. N. Shah, (1998) Stochastic frontier and technical efficiency of farms in irrigated areas of Pakistan s Punjab. *The Pakistan Development Review*.37; 275-291.

Battese, G.E, S.J .Malik and M.A. Gill.(1996) "An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan' *Journal of Agriculture Economics* . 47, 37-49.

Battese, G.E and G.S. Corra (1977) Estimation of a Production Frontier Model, With application to the Pastoral Zone of Eastern Australia" Australian Journal of Agriculture

Economics, 21 169-179

Battese, G.E and T. J. Coelli (1993) A Stochastic Frontier Production Function Incorporating a model for Technical Inefficiency Effect, Working paper no 69, October University of New England.

Battese, G.E (1992) Frontier Production Functions and Technical efficiency: A survey of empirical applications in agriculture economics, Agriculture Economics, 7:185-208

Battese, G.E. S.J. Malik and S Broco.(1993) Production Function for Wheat Farmers in selected Districts of Pakistan. An application of stochastic frontier production function with time varying inefficiency effects, The Pakistan Development Review, 32:233-68.

Battese, G.E and S.S. Broca (1997) Functional form of stochastic frontier production functions and models for technical efficiency effects: a comparative study for wheat farmers in Pakistan. Journal of Productivity Analysis, 8:395-414.

Battese, G.E, and S. Hassan (1999) "Technical Efficiency of Cotton Farmers in the Vehari District of Punjab Pakistan" *Pakistan Journal of Applied Economics* vol 15 NO 1&241-53

Bravo-Ureta, B.E. and E.R. Evenson (1994) Efficiency in agriculture production the case of peasant farmers in Eastern Paraguay, Agriculture Economics 10:27-37.

Bravo-Ureta, B.E. and A.E. Pinherio (1997) Technical economic and allocative efficiency in peasant farming, Evidence from the Dominican Republic. Development Economics 34:48-67.

Coelli, T.J (1994) A Guide to Frontier, Version 4.1 A Computer programme for Stochastic Frontier Production and Cost function Estimation, Armidale Australia

Coelli, T.J. and G.E. Battese (1996) Identification of Factors, which Influence the Technical Inefficiency of Indian Farmers, Australian Journal of Agriculture Economics 40: 103-128.

Coelli, T.J .(1996) A Guide to Frontier ,Version 4.1; A Computer programme for Stochastic Frontier Production and Cost function Estimation CEPA Working Paper No 7-96 *Department of Econometrics*, University of New England ,Armidale Australia.

Coelli, Timothy J,. Prasada Rao D.S, O'Donnell, and George, E. Battese(2005) "An Introduction to Efficiency And Productivity Analysis" second edition Springer Science + Business Media, Inc. 233 Spring Street, New York, NY 10013, USA.

Dhungana, B.R., P.L. Nuthall and G.V.Nartea.2004 Measuring the economic inefficiency for Naplease rice farmers using data envelopment analysis. The Australian Journal of

Agriculture and Resource Economics, 48:347-369.

Farrell, M. J. (1957) “The Measurement of Productive Efficiency” *The Journal of Royal Statistical Society Series* A 120, 253-90

Government of Pakistan (2011-12).Economic Survey of Pakistan 2011-12.*Finance Division, Economic Advisors Wing* Islamabad

Government of Pakistan (2011-12). Economic Survey of Pakistan 2011-12 Pakistan Bureau of Statistics, Islamabad, Pakistan

Government of Pakistan (2011-12) Economic Survey of Pakistan 2011-12, Pakistan Central Cotton Committee, Karachi

Gul, Melvut, Koc Besir, Dagistan Erdal, Akpinar Goksel M, and Oguz Parlakay (2009) Determination of technical efficiency in cotton growing farm in Turkey, A Case study of Cukurova Region, African Journal of Agriculture Research 4(10) 944-949

Hassan. S. (2004) An analysis of technical efficiency of wheat farmers in the mix farming system of the Punjab Pakistan. *Unpublished Ph.D Dissertation Department of farm management University of Agriculture* Faisalabad, Pakistan

Hussain, M.S.(1999). An analysis of efficiency of the cotton farmers in Punjab province Pakistan, *An unpublished Ph.D dissertation Graduate School of Agriculture and resource Economics University of* New England Armidale, Australia.

Kalirajan, K, P (1990) On Measuring Economic Efficiency. Journal of Applied Econometrics, 5:75-85.

Khan, M.H. and D. R. Maki, (1979) “Effects of Farm Size on Economic Efficiency; The Case of Pakistan” *American Journal of Agriculture Economics* 64-69.

Kumbhakar, S.C. and A. Bhattacharya (1992) Price distortion and Resource use efficiency in Indian Agriculture. A restricted profit function approach, Review of economics and statistics, 74:231-239.

Meeusen, W and J. Van den Broeck (1977) Efficiency Estimation from Cobb-Douglas production function with composed error,. *International Economic Review.*18; 435-444.

Parikh, A and K, Shah (1996) Measurement of Technical Efficiency in the North West Frontier Province of Pakistan, Journal of Agriculture Economics, 45 132-138.

Parikh, A. F. Ali and M.K. Shah (1995) Measurement of economic efficiency in Pakistani agriculture, American Journal of Agriculture Economics, 77:675-85.

Rauf, A.A.(1991).Education and Technical Efficiency during the Green Revolution in Pakistan .*Economic Development and cultural change*, 39; 651-665.

Shafiq, M. Rehman, T.(2000) The extent of resource use inefficiencies in cotton production in Pakistan's Punjab. An application of data Envelopment Analysis, Agric Econ, 22(3):321-330.

USDA (2012) World cotton supply and Distribution. Available online in http://www.fas.usda.gov/psdonline/[August 2012]