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Estimation of Technical Efficiency of Open Shed Broiler Farmers in Punjab, Pakistan: A Stochastic Frontier Analysis

Salamat Ali
Department of Agricultural & Applied Economics
The University of Agriculture, Peshawar-Pakistan
Email: alisalamat88@gmail.com

Shahid Ali
Department of Agricultural & Applied Economics
The University of Agriculture, Peshawar-Pakistan
Email: labeenali@gmail.com

Bakhtawar Riaz
Department of Agricultural & Applied Economics
The University of Agriculture, Peshawar-Pakistan
Email: Bakhtawar_riaz92@gmail.com

Abstract
This study was conducted to estimate the level of technical efficiency of open shed broiler farmers in Punjab, Pakistan. Data was randomly collected from 60 broiler farmers using multistage sampling technique during January-February, 2014. Stochastic frontier Cobb-Douglas production function was used for analysis of data. Maximum likelihood estimation technique was employed for estimation. The analysis revealed that the mean technical efficiency of open shed broiler farmers was 0.880 ranging from 0.440 to 0.985. This means that if the average broiler farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart than the average farmer could realize 10.50 per cent cost savings. In other words, with the same available resources and technology, an average broiler farmer could increase broiler production by 10.50 per cent. Similarly the most technically inefficient broiler farmer could reveal cost savings of 54.50 per cent. Results further showed that number of day old chicks, feed and labor positively and significantly affected broiler production while the effect of vaccination was negative and that of capacity of shed was positive but statistically insignificant. Results of technical inefficiency effect model revealed that with the increase in age, education and membership with association, technical efficiency of broiler farmers increased. Based upon these findings it is suggested that government and extension workers should educate open shed broiler farmers to use high quality day old chicks and feed for highest possible output and cost savings. Education programs for awareness among broiler farmers to use vaccinated day old chicks and quality resources for enhancing broiler production in the country is also a good policy option.
Keywords: Open Shed Broiler Farmers, Technical Efficiency, Stochastic Frontier, Cobb-Douglas Production Function, MLE, Punjab, Pakistan

1. INTRODUCTION

Poultry birds are reared throughout the world for economic value in the form of meat and eggs and certain by products. Poultry birds include hens (chickens), ducks, fowls, turkeys, pigeons etc. Broilers, layers and breeders are three different types of chicken on the basis of purposes. Broilers are produced for meat purpose; layers are kept for getting eggs while breeders are used for producing broilers and layers. World poultry meat production was 106.4 million metric tones (MMT) in 2013. Chicken meat output accounts for some 88 per cent of world poultry meat production. World chicken meat production was amount to about 93.00 MMT. American region is the leading continent in chicken meat production (41.2 MMT) followed by Asia (30.7 MMT), Europe (15.2 MMT), Africa (4.7 MMT) and Oceania (1.3 MMT) (FAO, 2013).

In 2013, ten Asian countries produced more than one million tones of chicken meat with a combined production of almost 25.85 MMT, representing 84.20 percent of the regional total and 27.78 of World chicken meat production. China is the leading chicken meat producer in the Asian region based on USDA data, between 2000 and 2013. China's chicken meat industry has expanded by almost 3.3 per cent a year. However, based on FAO data, chicken output of China in 2013 is closer to 13.5 MMT followed by India. India's chicken meat industry is one of the fastest growing in Asia. India's producers have had to adjust to much higher feed costs; domestic forecasters confidently predict growth to continue at between eight and ten per cent a year with output of around 3.4 MMT. Chicken meat output in Iran has risen by some seven per cent a year from 0.804 MMT in 2000 to almost 1.9 MMT tones in 2013 followed by Indonesia (1.6 MMT), Turkey (1.7 MMT), Malaysia (1.4 MMT), Japan (1.2 MMT), Thailand (1.23 MMT), Myanmar (1.08 MMT), Philippine (0.94 MMT) and Pakistan

(0.91 MMT) (FAO, 2013).

The demand for poultry is expected to continue growing in developing economies, particularly in China, India and Pakistan reflecting population increase, improved disposable incomes and consumer taste preferences. Per capita chicken meat consumption in world, developed countries, developing counties and Pakistan are presented in table 1.

Table 1 Per capita chicken meat consumption in World and Pakistan during 2011-2012

Per capita chicken meat consumption	2011	2012
World (kg/year)	42.5	43.0
Developed countries (kg/year)	78.7	79.1
Developing countries (kg/year)	32.5	33.1
Pakistan (kg/year)	3.0	3.1

Source: FAO, 2012.

Poultry industry is the second largest industry after textile in Pakistan. Poultry has shown very rapid growth and its contribution in GDP has increased. It contributes 6.4% to agriculture GDP and 11.5% to livestock. In Pakistan poultry sector is generating employment opportunities (direct or indirect) and it provides income opportunities for 1.5 million people. Current investment in poultry sector is 200.00 billion. The poultry sector has shown a growth rate of 8 to 10% annually (GoP, 2012). Poultry farming provides quick return on investment. It can be started with less investment as a cottage industry. It will help in reducing demand of beef and mutton in future (Ahsan and Masood, 2004).

In Pakistan, Punjab is the leading province with amount of 709.50 million number of broilers followed by KPK (31.47 million number), Sindh (16.19 million number), Balochistan (7.08 million number) and Northern area (0.54 million number) (GoP, 2012). In Punjab province Rawalpindi division had 3267 broiler farms followed by Lahore (2958), Faislabad (2687), Multan (2629) Gujranwala (2387), D.G. Khan (1638), Bahawalpur (1577) and Sargodah (1456) (Govt. of Punjab, 2012).

In Pakistan poultry business has changed from subsistence to commercial poultry farming but small poultry farmers are not fully aware of use and allocation of scarce resources in broiler production. Literature reveals that the main objective of the firm is to maximize the profit either by increasing output or reducing cost of production. Broiler production like any other agribusiness is dependent on allocation of resources, the maximum poultry production depends partly on the environment, technical know-how and the quality of resources employed in the production process.

FAO statistics unveils that Pakistan is far behind in chicken meat production in world as well as in Asia. Chicken meat production can be increased by increasing broiler productivity. In Pakistan poultry farmers are not fully aware of use and allocation of scarce resources in broiler production. Increase in productivity can be divided into two components; i) innovations that create new and/or improved inputs and techniques of production and new uses for existing products and ii) growth in the efficiency of the use of these technologies. The latter requires technological capability like technical, managerial and institutional skills and building such capabilities in harmony with the dynamism of changing technologies (Kalirajan, 1991 and Lall, 1993). In economics the term efficiency was first introduced by Farrell (1957). Farrell work was based upon the work of Debereu (1951) and Koopsman (1951). Level of efficiency was measured either by Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA). DEA approach was first applied by Farrell (1957) while SFA approach was first applied by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977), independently. Stochastic frontier models are widely used in the analysis of efficiency, particularly in developing countries. Battese and Hassan (1998) evaluated technical efficiency cotton farmers in Pakistan. Kalirajan and Shand (1986) studied firm specific technical efficiency in Malaysia. Lundvall and Battese (1998) analyzed firm size and age efficiency in Kenya. Previously no application of stochastic frontier model for the analysis of technical efficiency of broiler farmers in Pakistan has been carried out. Therefore, there is an intense need to fill the gap and estimate the level of technical efficiency of open shed broiler farmers in the study area.

Based upon the aforesaid discussion this study estimated the level of technical efficiency of broiler farmers in the study area. The estimated coefficients of explanatory variables and inefficiency factors in production of broilers are of immense importance. Government and policy makers can use these estimates for boosting up broiler production in Pakistan. In future, researchers can get help from the findings of this research. From the findings of this study broiler farmers and other stakeholders involved directly or indirectly in broiler business will also be benefited. It will also help to identify the input issues that cause lower productivity in broiler farming and will suggest some policy guidelines to increase the broiler production in the country. Therefore, present study was designed to estimate stochastic frontier production function for measuring technical efficiency of open shed broiler farmers and to measure the determinants of technical inefficiency that affected technical efficiency of broiler farmers.

2. DATA AND METHODOLOGY

2.1 Universe, sampling technique and sample size of the study

This study was conducted in Rawalpindi Division of Punjab, Pakistan. For selection of sample size, multistage sampling technique was applied. In the first stage, Rawalpindi Division was purposively selected because it is the major broiler producing division of Punjab province (GoP, 2012). In stage second four districts were randomly selected. In stage third, from each district 8 villages were randomly selected from a list of major broiler producing villages. In the fourth and last stage, a sample of 60 open shed broiler farmers were randomly selected through proportional allocation sampling technique (Cochran, 1977; Choudry and Kamal, 2010; Pandey and Verma, 2008).

$$n_i = n^* (N_i/N) \quad (1)$$

Where;

n_i = Number of sampled broiler farms in ith district.

n = Total sample size.

N_i = Total number of broiler farms in ith district.

N = Total number of broiler farms in the study area.

Table 2 Population and sample size of broiler farms in Rawalpindi Division

Districts	Number of poultry broiler farms	Sample size
Chakwal	1519	28
Rawalpindi	865	16
Jhelum	525	10
Attock	358	06
Total	3267	60

Source: Statistical Report of PPRI, 2012.

2.2 Data collection

A well structured interview schedule with both close ended and open-ended questions was primed for collection of primary data from the broiler farmers. The sampled farmers were interviewed personally either at their farms or at offices. Through this research the farmers were provoked in order to obtain exact and relevant data for accurate results. Secondary data were collected from different government and official sources e.g. Government of Pakistan, Punjab Poultry Research Institute (PPRI) Rawalpindi, Economic Survey of Pakistan and Agriculture Statistics of Pakistan.

2.3 Analytical framework

2.3.1 Modeling

Farrell in 1957 was pioneer of measuring efficiency drawing on the work done by Koopmans (1951) and Debreu (1951). He decomposed efficiency in three components i.e. technical, allocative and economic efficiency. The ability of firm/farm to produce maximum level of output from available inputs is called technical efficiency. The ability of a firm to use inputs in best possible proportions, given their relative prices and available technology is referred to as allocative efficiency. The product of technical efficiency and allocative efficiency is termed as economic efficiency.

Stochastic frontier production function is utilized to evaluate technical efficiency of a firm. Two main methods are used to measure efficiency frontier. The first of these is the nonparametric approach; in this approach linear programming is used which is known as Data Envelopment Approach (DEA) and free disposal hull (FDH). The difference between FDH and DEA method is that FDH was developed by Deprins, *et al* (1984) while the DEA method was initiated by Farrell (1957) and transformed into estimation techniques by Charnes, *et al* (1978). In DEA method no assumption is made on the error term and no functional form on the production frontier even so, this method is limited because:

i. It has not statistical procedure for testing of hypothesis.
ii. It does not have error term it means that every variation from the frontier erect firm's inefficiency.
iii. It is very sensitive to outliers and extreme values.

Parametric approach is the second method which is based on econometric theories whose functional form is specified. In this approach, the stochastic frontier approach is the most popular, referred to as "composed error model", the stochastic frontier approach has the advantage of taking error term.

The stochastic frontiers approach was applied in this study on the basis of the inconsistency in field of agriculture, which is attributable to environmental hazards, attack of diseases and management practices in one hand and information collected on production is usually inaccurate because small farmers do not have updated data on their farm operations. In fact, the stochastic frontier approach makes it possible to estimate a frontier function that simultaneously takes into account the random error and inefficiency factors specific to every farmer.

2.3.2 Stochastic frontier production function

The stochastic frontier production frontier function was independently proposed by Aigner *et al*. (1977) and Meeusen and van den Broeck (1977).

$\ln Y_i = X_i \beta + v_i + u_i$ where $i = 1, 2, 3, \ldots, N$ (2)

Where Y_i is the production obtained from ith farm, X_i shows the input used by the ith farm, β is the unknown parameters to be estimated, v_i sets for symmetry error, accounts for the random variation in production due to factors which are beyond the control of the poultry farmers. Aigner *et al*. (1977) assumed that v_i's having independently and identically distributed as N $(0, \sigma^2_v)$ independent of the u_i's, u_i's is a non negative random variable. It is also related with farm specific factors which are in control of the farmer, associated with technical inefficiency of the poultry farm, independently and identically distributed exponential as N $(0, \sigma^2_u)$ i.e. half normal distribution having value between 0 and 1.

2.3.3 Empirical model for estimation of technical efficiency

The farm specific technical efficiency is ratio of observed output (Yi) to the corresponding frontier output (Y_i*) using the available technology. Hence technical efficiency of broiler farmers is given as.

$TE_i = \exp(-\mu_i) = Y_i / Y_i^*$ (3)

Technical efficiency takes values ranging from zero to one, where 1 stands for fully efficient firm and 0 indicates for inefficient.

Production technology of farmers is assumed to be specified by stochastic production function representing Cobb-Douglas production technology (Henderson and Quant (1971)), which was specified as follows:

$\ln Y_i = \beta_0 + \beta_1 \ln Chicks + \beta_2 \ln Feed + \beta_3 \ln Labor + \beta_4 \ln Vaccin + \beta_5 \ln CapShed + (v_i + u_i)$ (4)

Where;

Y_i = Production of broiler in kilograms per shed
Chicks = No of day old chicks per shed
Feed = Feed intake in kilograms per shed
Labor = Number of labors in man days per shed
Vaccin = Number of vaccinations per shed
CapShed = Capacity of shed (Number of broilers)
vi = Natural error term i.e. $N \sim (0, \sigma^2_v)$
ui = Technical inefficiency error i.e. $N \sim (0, \sigma^2_u)$
ln = Natural logarithm

β_0 and β_i are the parameters to be estimated.

2.3.4 Determination of technical inefficiency of broiler farmers

In order to determine factors contributing to the observed technical inefficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure (Coelli, 1996). The model is given as fallows:

$\mu_i = g(Z_i : \delta_i)$ (5)

$\mu_i = \delta_o + \delta_1 AGE + \delta_2 EXP + \delta_3 EDU + \delta_4 CRED + \delta_5 MEMB + \omega_i$ (6)

Where;

μ_i = Technical inefficiency.
AGE = Age of the poultry farmers in years.
EXP = Farming experience of the poultry farmers in years.
EDU = Education of the poultry farmers in years.
CRED = Dummy variable (credit access yes =1, No = 0)
DMEM = Dummy variable for membership with poultry association/cooperatives,
DMEM = 1, if broiler farmer is member of poultry association/cooperatives
DMEM = 0, otherwise.
ω_i = Random error term.

δ_o and δ_i are the parameters to be estimated.

2.3.5 Determination of technical efficiencies of individual open shed broiler farmers

For the estimation of technical efficiencies of individual open shed broiler farmers, the following formula was applied.

$TE_i = Y_i / Y_i^*$ (7)

Where;

Y_i = Observed output of ith farm
Y_i^* =frontiers output of ith farm that can be achieved
TE_i = Technical efficiency of ith farm that ranges between 0 and 1.

For the estimation of technical inefficiency of individual wheat farms, the following formula was applied.

$TI_i = 1 - TE_i$ (8)

$TI_i = 1 - [Y_i / Y_i^*]$

Where;

TI_i = Technical inefficiency of ith farm that ranges between 0 and 1.

2.4 Model adequacy/diagnosis tests

Following model adequacy/diagnostic tests were performed to test the robustness of the estimates of the stochastic frontier Cobb-Douglass production model.

2.4.1 Normality tests

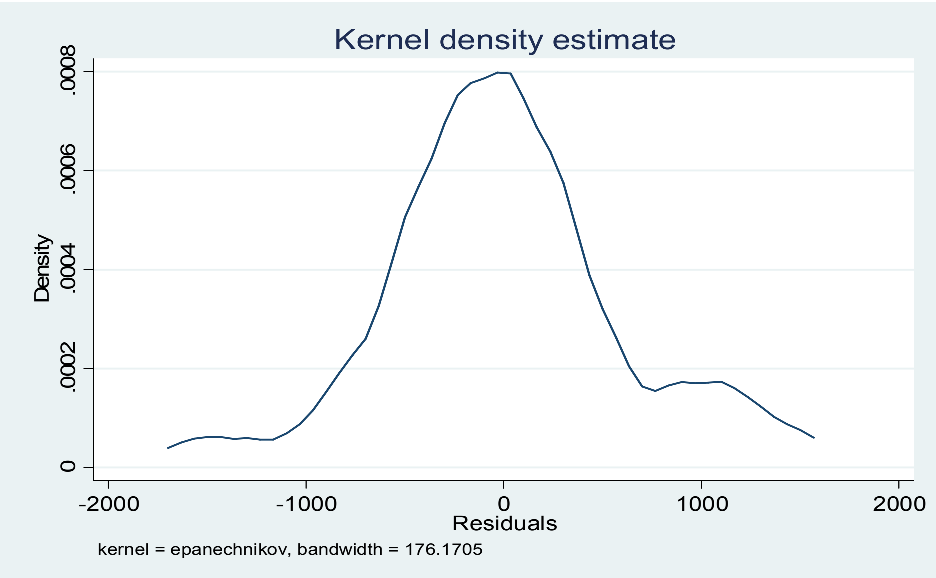
Normality of residuals is only required for valid hypothesis testing, that is, the normality assumption assures that the p-values for the t-tests and F-test will be valid. Normality is not required in order to obtain unbiased estimates of the regression coefficients. OLS regression merely requires that the residuals (errors) be identically and independently distributed.

i. Shapiro-Wilk W test

The p-value is based on the assumption that the distribution is normal. In this study, it is large (0.14644), indicating that we cannot reject the hypothesis that data is normally distributed.

ii. Kdensity test

Kdensity stands for kernel density to produce a kernel density plot with the normal option requesting that a normal density be overlaid on the plot



2.4.2 Heteroscedasticity tests

The assumption of the homoscedasticity of the classical linear regression model is that the variance of each disturbance term μi for the chosen values of the dependent variables is a constant number equal to σ^2. Symbolically it can be written as:

$E(\mu_i^2) = \sigma^2 \qquad i = 1,2,\ldots..,n$

If the aforementioned assumption is violated then it will lead to a problem of heteroscedasticity, which means that variance of the error term will no more remain constant. The consequence of heteroscedasticity is an unbiased but inefficient estimate of the coefficients. The results of the variances which may be small or large, leading to type I or type II error in the presence of heteroscedasticity which means that OLS is no not BLUE (Best Linear Unbiased Estimator). Heteroscedasticity is mainly present in cross sectional data as ours, than time series data (Gujarati, 2009).

i. White's test

White's test for heteroscedasticity follows χ^2 distributions. The estimated p-value was 0.1681 and statistically insignificant at all levels of significance. So we can not reject the null hypothesis of homoscedasticity.

ii. Breusch-Pagan test

Breusch-Pagan test for heteroscedasticity also follows χ^2 distributions. The estimated p-value was 0.3705 and statistically insignificant at all levels of significance. So we can not reject the null hypothesis of homoscedasticity. This result reinforces our hypothesis of homoscedasticity

2.2.3 Model specification tests

A model specification error can occur when one or more relevant variables are excluded from the estimated model or one or more irrelevant variables are incorporated in the estimated model. If relevant variables are omitted from the model, the common variance they share with included variables may be wrongly attributed to those variables, and the error term is inflated. On the other hand, if irrelevant variables are included in the model, the common variance they share with included variables may be wrongly attributed to them. Model specification errors can substantially affect the estimates of regression coefficients (Gujarati and Porter, 2009). There are a couple of methods to detect model specification errors; i) the link test and ii) Ramsey's RESET test.

i. The link test

The link test is based on the idea that if a regression is properly specified, one should not be able to find any additional independent variables that are significant except by chance. The link test follows χ^2 distributions.

The estimated p-vale of link test was found to 0.581 and statistically insignificant. This implies that link test has failed to reject the assumption that the model is specified incorrectly. Therefore, it seems that we are not committing model specification error. But now, let's look at another test.

ii. Ramsey's RESET test

Ramsey's RESET test is another test of regression model specification error. It performs a regression specification error test (RESET) for omitted variables. The idea behind Ramsey's RESET test is very similar to link test. Ramsey RESET test follows F distribution (Gujarati and Porter, 2009).

As our F calculated (0.44) is less than F tabulated ($F_{0.05\,(5,\,55)}$ = 2.53), therefore, the null hypothesis of no model specification error can not be rejected. We can conclude that there is no specification error in the estimated model. This result reinforces our conclusion that the model is correctly specified and all the relevant variables are incorporated in the estimated model.

2.2.4 Log likelihood ratio (LR) test for detection of technical inefficiency

LR test is performed to test the presence/absence of technical inefficiency in the stochastic frontier Cobb-Douglas production model. The formula for the LR test statistic is as follows:

$$\text{LR statistic} = 2\,[\,\ln H_0 / \ln H_1\,] = -2\,[\,\ln H_0 - \ln H_1\,] \quad (7)$$

Where $\ln H_0$ denotes the log likelihood of the model when it is assumed that inefficiency is not present in the estimated model and $\ln H_1$ is the log likelihood of the model when it is assumed that inefficiency is present. If LR statistic is significant, then we reject the null hypothesis of no technical inefficiency. LR test follows χ^2 distributions.

As our calculated LR statistic (20.38) is greater than tabulated χ^2 (11.07) so, the null hypothesis of no technical inefficiency was rejected and suggested the inclusion of inefficiency factors in the model.

3. RESULTS AND DISCUSSION

3.1 Summary statistics of variables used in stochastic frontier analysis of open shed farms

Table 3 shows summary statistics of variables used in stochastic frontier analysis for open shed broiler farms. Average production and standard deviation was 5082.17 kg per shed and 2766.93 respectively for open shed broiler farms. The standard deviation shows large variability of production among the farmers. The minimum production for open shed was 747.50 kgs and maximum production was 10860.00 kgs. Average number of day old chick per shed was 3395.00, with a minimum value of 1000.00 and maximum value of 6200.00 for open shed broiler farms. The average feed used per shed was 12,061.66 kgs having a minimum value of 3000.00 and a maximum of 19,750.00 and standard deviation of 5,043.77. The average labors, including family labors were 53.71 man days per shed.

Table 3 Summary statistics of the variables used in stochastic frontier Cobb-Douglas production function of open shed broiler farms

Variables	Units	Mean	Std. Dev.	Minimum	Maximum
Output	Kg	4849.50	2766.93	747.50	10860
Day old chicks	No	3395.00	1402.22	1000.00	6200.00
Feed	Kg	12061.66	5043.77	3000.00	19750.00
Labor	M Days	53.71	7.29	40.00	71.00
Vaccination	Rs	32890.00	20974.48	4000.00	99000.00
Capacity of shed	No	3750.00	1502.82	1000.00	10000.00
Age	Years	39.75	8.94	25.00	57.00
Experience	Years	11.85	7.79	0.00	30.00
Education	Years	8.95	4.23	0.00	14.00
Credit access	Dummy	0.50	0.50	0.00	1.00
Membership	Dummy	0.55	0.50	0.00	1.00

Source: Estimated from survey data, 2014.

The average vaccination cost was Rs. 32,890 with standard deviation of 20,974.48. Average capacity of shed was 3750.00 having a minimum value of 1000.00 and a maximum of 10000.00 with a standard deviation of 1502.82. Average age of open shed farmers was 39.75 years. On average open shed farmers were having 11.85

years of poultry rearing experience. Average schooling years of open shed were 8.95 years. On average credit access of open shed farmer was 0.50. Average membership status of farmer was 0.55.

3.2 Maximum likelihood estimates of the stochastic frontier production function of open shed broiler farmers

Table 4 shows estimates of stochastic frontier Cobb-Douglas production function for open shed broiler farms. The estimated coefficient of day old chick was found to be 0.7142 and statistically significant at 1 percent level of significance. This means one percent increase in day old chicks brings about 0.714 percent increase in broiler production. These results are in conformity with the findings of Ohjaniya *et al*. (2013), Effiong (2005) and Nwachukwa and Onyenweaku (2007).

Table 4 Maximum likelihood estimates of the stochastic frontier production function of open shed broiler farmers
Dependent variable = log output of broilers

Variables	Parameters	Coefficients	Standard error	T- ratios
Constant	β_0	-2.4899	0.6616	-3.7866*
Day old chicks	β_1	0.7142	0.2103	3.40*
Feed	β_2	0.5172	0.1751	2.95*
Labor	β_3	0.4364	0.1802	2.42*
Vaccin	β_4	0.0708	0..0660	1.07
Capacity of shed	β_5	-0.2487	0.1159	-2.15
Technical inefficiency effects model				
Constant	δ_0	3.8400	2.5008	1.54
Age	δ_1	-0.1925	0.0978	-1.97**
Experience	δ_2	0.0864	0.1023	0.85
Education	δ_3	-0.1295	0.0753	-1.72**
Credit access	σ_4	1.2820	0.7537	1.70**
Membership	δ_5	-1.2335	0.7030	-1.75**
Sigma u^2	σ_u^2	0.06341		
Sigma v^2	σ_v^2	0.00605		
Sigma^2	σ^2	0.06949		
Gamma (σ_u^2 / σ^2)	.γ	0.91282		
Mean TE	X_{mean}	0.880		
Minimum TE	X_{min}	0.440		
Maximum TE	X_{max}	0.985		

* and ** indicates significance at 0.01 and 0.05 probability, respectively.
Source: Estimated from survey data, 2014.

The estimated coefficient of feed was found to be 0.5172 and statistically significant at 1 percent level of significance. This implies that if the application of feed increased by one percent then the broiler production in kg increased by 0.5172 percent. These findings are in conformity with the findings of Udoh and Etim (2009), Ohjaniya *et al*. (2013), Ezeh *et al*. (2012) and Belbase and Grabowski (1985) while opposite to the results of Alwris and Francis (2003) and Ike (2011).

The estimated coefficient of labor was 0.4364 and statistically significant at 1 percent level of significance. This implies that a one percent increase in labor increases broiler production by 0.4364 percent. This result is in accordance with the results of Ohjaniya *et al*. (2013), Lwueke (1987) and Ezeh (2006) while opposes the results of Ezeh *et al*. (2012) and Areet *et al*. (2012) who found negative relationship between labor and broiler production.

The coefficient of vaccination cost was found to be statistically insignificant. The effect of vaccination cost is insignificant on broiler production because all the broiler farmers in study area were applying approximately same number of vaccination having same cost. These results are similar to the results of Oleke and Isinnika (2011) and Ezeh *et al*. (2012) while in contrast to the results of Ike (2011).

The coefficient of capacity of shed in the broiler production was found to be -0.2487 and statistically significant at 5 percent level of significance. This implies that capacity of shed has negative effect on broiler production that is a one percent increase in capacity of shed decreases broiler production by 0.2487 percent. These findings oppose the findings of Ike (2011) who found a positive relationship between capacity of shed and broiler production. Farmers of open shed in study area mismanage space for broilers and when they increase day old chicks more than the recommended capacity of shed; it leads to have negative effect on broilers productivity.

The lower part of table 4 presents the effects of technical inefficiency factors on broiler production in study area. Results reveal that the coefficient of age was negative and statically significant at 5 percent level of significance. This means that technical inefficiency decreases with the increase in age of broiler farmers. In other words technical efficiency increases with the increase in age of farmers. These results are similar to the findings of Oluwatusim (2011), Ezeh *et al*. (2012) and Nawaru (2005) and contrary with the findings of Alwris and Francis (2003) and Oleki and Islinka (2011)

The coefficient of experience of broiler farmer was positive and statistically insignificant at all level of significance. This means experience of farmer has no significant effect on technical inefficiency/efficiency of broiler farmer in study area. These results are in contrast to the results of Alwris and Francis (2003) and Ike and Inoni (2006) who found that experience has significant effect on technical efficiency/inefficiency.

The estimated coefficient of education was negative and statistically significant at 5 percent level of significance. These results are consistent with the findings of Lgwe (2004) and Onyenweakuctal (2005) while in contrast with the findings of Ezeh *et al.* (2012) who found a positive relationship between education and technical inefficiency.

The coefficient of credit access was positive and statistically significant at 5 percent level of significance. This implies that credit access of farmers increase the technical inefficiency in study area. The same results were found by Oleki and Islinka (2011). These results are different from the results of Areet *et al.* (2012) who found negative relationship between credit access and technical inefficiency.

The estimated coefficient of membership with farmers' associations/cooperatives was negative and statistically significant at 5 percent level of significance. This means that technical inefficiency decreases with the increase with membership of farmers with association/cooperatives. These findings are in contrast to the results of Ezeh *et al*. (2012) who found statistically insignificant relationship between membership and technical inefficiency.

The estimated value of mean technical efficiency was found to be 0.88 ranging from 0.44 to 0.985. This means that if the average broiler farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 10.50 per cent cost savings. In other words, with the same available resources and technology, an average broiler farmer could increase broiler production by 10.50 per cent. Similarly the most technically inefficient broiler farmer reveals cost savings of 54.50 per cent.

3.3 Individual technical efficiencies of open shed broiler farmers

The estimated technical efficiencies of individual broiler farmers are presented in the table 5.

Table 5 Individual technical efficiencies of open shed broiler farmers

S. No	TE	S. No	TE	S. No	TE	S. No	TE
1	0.927	16	0.904	31	0.977	46	0.883
2	0.764	17	0.877	32	0.885	47	0.960
3	0.912	18	0.850	33	0.961	48	0.907
4	0.888	19	0.897	34	0.440	49	0.980
5	0.937	20	0.958	35	0.942	50	0.973
6	0.916	21	0.971	36	0.875	51	0.842
7	0.864	22	0.937	37	0.912	52	0.760
8	0.867	23	0.984	38	0.989	53	0.913
9	0.952	24	0.951	39	0.952	54	0.853
10	0.907	25	0.855	40	0.571	55	0.763
11	0.969	26	0.900	41	0.616	56	0.906
12	0.927	27	0.479	42	0.961	57	0.962
13	0.926	28	0.883	43	0.904	58	0.963
14	0.926	29	0.837	44	0.833	59	0.885
15	0.956	30	0.966	45	0.931	60	0.930

Source: Estimated from survey data, 2014.

3.4 Frequency distribution of technical efficiency of open shed farms

Table 6 shows the estimated technical efficiency's frequency distribution of broiler farmer of open shed. The minimum and maximum values for estimated technical efficiencies are 0.440 and 0.985 with a mean efficiency of 0.880, which shows that majority of the farmers that is about 55 percent of the sample respondent in the study area, have technical efficiency of above 0.90.

Table 6 Frequency distribution of technical efficiency of open shed farms

TE class interval	Frequency	%
> 0.50	2	3.33
0.50-0.60	1	1.66
0.61–0.70	1	1.66
0.71–0.80	4	6.66
0.81–0.90	19	31.66
0.91–1.00	33	55.00
Sample size	60	100
Minimum TE	0.440	-
Maximum TE	0.985	-
Mean TE	0.880	-

Source: Estimated from survey data, 2014.

4. CONCLUSION AND RECOMMENDATIONS

This study was carried out to estimate the level of technical efficiency of open shed broiler farms in Rawalpindi division, Punjab. Multistage sampling technique was used for selection of sampled respondents. A total of 60 farmers of open shed boilers farms were interviewed from the selected districts by proportional allocation technique. A comprehensive interview schedule was used for collection of data. For the estimation of technical efficiency of broiler production and determination of the relationship between dependent and independent variables, a stochastic production frontier function was used. Stata (version 12) computer program was used for the analysis of data.

Maximum likelihood estimates of the stochastic frontier Cobb-Douglas production function revealed that number of day old chicks, feed and labor for open shed were statistically significant with positive coefficients and capacity of chicken in shed was negative but statistically insignificant for open shed farms. The estimated value of gamma was 0.93; this means that about 93% variation in the production of open shed broilers was due to inefficiency factors of the farmers. The estimated mean technical efficiency was 0.88 ranging from 0.44 to 0.985. This means that if the average broiler farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 11 per cent cost savings. In other words, with the same available resources and technology, an average broiler farmer could increase broiler production by 12 per cent. Similarly the most technically inefficient broiler farmer reveals cost savings of 55 per cent.

The findings revealed that education is the significant factor which affects the technical efficiency of farmers of open shed. So the government should offer educational programs for awareness among the farmers to apply quality day old chicks and feed for fostering broiler production in the country. Broiler farmers have to become member of association for easy purchase of vaccinated day chicks and quality feed and sale of chickens at appropriate price in the market. Similar studies need to be replicated in other major broiler producing areas of the country.

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