

## ROLE OF SOCIO-ECONOMIC FACTORS ON SCALE EFFICIENCY OF COTTON FARMS

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### Abstract

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The increasing need of food and fibre is a big challenge around the globe especially for the researchers. The cotton is one of the important crops all over the world as well as in the study area which contribute in textile industry as well as a number of food items. In context of Pakistan, cotton contributes directly or indirectly in exports, hence, earning foreign exchange. In this regard, socio-economic factors play important role in the agricultural production and Scale Efficiency (SE) measure is one of the most important indicators which can show the influences of varying range of the endowment and socio-economic factors. This piece of work contributes by estimating the SE of the cotton farms in selected study area. Moreover, it describes the influences of socio-economic factors on SE of cotton farms. To estimate the SE, Data Envelopment Analysis (DEA) method has been used. For the determination of influences of socio-economic factors, Tobit censored linear regression (parametric) and Kruskal Wallis & Bonferroni comparison tests (non-parametric) analyses have been considered. In total seven socio-economic factors; agriculture farm type, farm machinery, farm size, farmers' age, qualification, experience and working style of the farmers have been considered. It was found that farm size and farmers working style have, statistically, very significant influences on SE of cotton farms and farmers working as part time are the most efficient. Moreover, renters' cotton farms are more efficient than owners' farms. It was also concluded that social factors influence SE, statistically, insignificantly. However, old aged farmers are more efficient than the young farmers, farmers having university education are more efficient than the other levels, and most experienced farms are the most efficient.

**Key words:** agricultural farms, socio-economic factors, Tobit regression analysis, data envelopment analysis, Kruskal Wallis test

### Introduction

In context of Pakistan, cotton contributes directly or indirectly in exports, hence, earning foreign exchange. In this realm, it is very important to enhance to production of cotton crop. According to Pakistan Bureau of Statistics (2014), about 2806 thousands hectares of land is cultivated with the cotton crop and it produces about 12 769 thousand of bales of 375 pounds each. With the information that a large number of hect-

ares are utilized to produce cotton, it is important that natural as well other resources should be used efficiently which will enhance the livelihood of the agricultural farmers as well as it will also contribute in the national earnings, efficiently. Considering the bestowed and human managed resources, socio-economic factors play important role in the agricultural production and Scale Efficiency (SE) measure is one of the most important indicators which can show the influences of varying range of the endowment and socio-economic factors. Agricul-

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ture farming is a complex process. For efficient production, a number of factors need to be considered. As per Passel et al. (2006) economic factors; farm type (tenure or ownership), farm size, farm machinery and social factors; farmers' age, education, experience & other human skills, and environmental factors such as, soil, crops cultivated, infrastructure, markets, government policies, and international trade contribute directly or indirectly in the production process of agriculture farming. Moreover, a number of activities such as selection of seed, varieties, fertilizers, pesticides/weedicides, seed bed preparation, use of water, and selection of market to sell the products influence the farms' efficiency. In this regard, best use of resources and best selection of the technological options may enhance the crop production efficiently. The most efficient farmer would be that who chooses the input bundle which contributes to a maximum feasible bundle of output(s) or inversely chooses a smallest possible input bundle that can produce a given level of output or some combination of the two. It is very important to identify the bundles of inputs which improve the efficiency of crop production. In this realm, this paper contributes by estimating the cotton crop's scale efficiency (SE) and by identifying its influencing economic factors; farm type, farm size, and farm machinery and social factors; farmers' age, qualification, experience, and working style in the study area.

One can find a number of definitions of efficiency in literature and it can be described in different terms such as technical efficiency (TE), scale efficiency (SE), and allocative efficiency (AE). SE is the ratio of TE (constant return to scale – CRS) to TE (variable return to scale – VRS). TE is a comparison between observed and optimal values of output and inputs of a production unit (Sadoulet and Janvry, 1995). Therefore, this comparison takes the form of the ratio of observed to maximum potential output attainable from the given inputs, or the ratio of the minimum potential to observed input required to produce the given output(s), or some combination of the two. A productive entity is technically inefficient when it is not producing the maximum output possible, or given its output, it is using more inputs as compared to required ones (Sadoulet and Janvry, 1995). In this study SE has been considered because to calculate SE both constant and variable returns to scale are considered where as in case of TE only one; variable or constant returns to scale is considered. In case of TE, a production may be efficient in variable return to scale but not in constant return to scale or vice versa but in case of SE, an efficient production is efficient in both cases. Hence, SE explains better than TE. According to Zyl et al. (1995), farm size in relationship with the efficiency has its origin in SE and not in the TE or AE. Hence, this article describes the SE of cotton farms.

Although a number of studies as discussed in the literature could be found which have focussed on the efficiency of cotton production around the globe but in the selected study area of south Punjab of Pakistan, no study has been found in the literature explaining the influences of socio-economic factors on cotton farms' SE. Moreover, cotton crop is one of the four major crops (cotton, wheat, rice and sugarcane) as well as a cash and fibre crop which contributes in foreign exchange. In this way, the contribution of this study is very important for farmers, researchers, and policy makers. Hence, the objective of this study is to estimate the SE and testing the influences of socio-economic factors on cotton farms.

### Studies on Agriculture Productivity and Efficiencies

In literature, a number of studies concerning the calculation of efficiencies and models used to estimate the efficiencies could be found. For example, Solakoglu et al. (2013) studied the TE of cotton production in Turkey by using maximum likelihood method and found that decision of production depend on market prices as well as on support prices and premiums which were paid to the farmers increased the cotton production TE. Similarly, Chou et al. (2012) used DEA to calculate SE in tourism and Kim (2001) compared the SE scores of conventional and sustainable farms. The analysis included DEA-CCR (Charnes Cooper Rhodes) and DEA-BCC (Banker Charnes Cooper) models for efficiency calculations. The author found that sustainable farms had more profitable input/output relationship than conventional farms. Moreover, De-Koeijer et al. (2002) have measured sustainability based on socio-economic and bio-ecological attributes. The authors have used DEA models to measure the sustainability of a group of Dutch sugar beet growers over four consecutive periods of time. Gomes (2009) assumed sustainability as being a mix of environmental efficiency plus economic performance. In his words "if farmers improve the TE of their use of polluting inputs, they simultaneously achieve economic and environmental objectives". It means that improvements of TE may support sustainability. In another work, Abay et al. (2004) analyzed DEA-CCR efficiency measurements of input use in tobacco production in Turkey with respect to sustainability. The results showed a positive relationship between the efficiency of inputs used and sustainability of agriculture. Rodríguez-Díaz et al. (2004) used DEA-BCC models to evaluate the most efficient irrigation districts in Andalusia (Spain) relative to water use. The authors believed that the study of efficiency allows them to assess when the use of water leads to greater profitability.

Hence, the results may help to improve water management. Sauer and Abdullah (2007) studied tobacco production in Tanzania. The authors were looking for the existence of empirical relations among production efficiency, biodiversity, and resources use. The results suggested that an increase in tobacco production efficiency is conducive to environmental sustainability in Tanzania. Gomes and Lins (2007) used DEA models to evaluate sustainability in agriculture. Several variables were taken into account and the resulting efficiency was measured by comparison.

Sustainable and efficient farming systems have been historically dependent on constant productivity for long periods of time. During the last decades, sustainability has become a variable that needs to be analysed and measured (Carpenter, 1993). In agriculture, sustainability involves physical, biotic, economic feasibility and socio-cultural factors. Similarly, it is important to mention, for instance, Von (2001) work on the sustainable agriculture theme. There are several approaches in the literature to evaluate agricultural efficiency and sustainability. In this concern, the studies by Ali (1996); Pannell and Glenn (2000); Rigby et al. (2001); Praneetvatakul et al. (2001); López-Ridaura et al. (2002); Herendeen and Wildermuth (2002); Lopes and Almeida (2003); Zhen and Routray (2003); Pacini et al. (2003) and Fernandes (2004) are worthy to be mentioned. In addition to DEA models, some of the researchers also have used the Stochastic Frontier Analysis (SFA) models to estimate the TE. However, most of the authors have proposed the use of DEA models to measure agricultural efficiency. For detail please consult the studies by Kim (2001); De Koeijer et al. (2002); Abay et al. (2004); Rodríguez Díaz et al. (2004); Bosetti and Locatelli (2006) and Sauer and Abdullah (2007).

Passel et al. (2006) studied the factors of farm performance through an empirical analysis of structural and managerial characteristics. The authors classified the explanatory variables that influence the farm efficiency into two groups: first, agent factors comprising of age, education, and experience of the farmer or farm manager; and secondly, the structural factors which include on-farm factors and off-farm factors. On-farm factors examples could be location of farm, farm type, and size of farm while off-farm examples could be up-downstream relations, policy, etc. The authors found that many managerial and structural characteristics are linked to farm performance. They concluded that the farm size, farm accounting and having a high share of own land have a positive effect on efficiency. On the other hand farm solvency, farmer's age and farmers' dependency on support payments are negatively related to farm efficiency.

## Materials and Methods

Primary data on agricultural farm level was collected with the help of a well-structured questionnaire in 2012. Data was collected for cotton output and 6 input variables including; land, urea, di-ammonium phosphate, pesticides, and weedicides from 142 farmers in two districts (Dera Ghazi Khan and Rahim Yar Khan) in south Punjab, Pakistan. In order to avoid the multi-collinearity and other related problems, urea and di-ammonium phosphate were added together as total fertilizers. Similarly, pesticides and weedicides were added together as total chemicals. All of the variables were measured in absolute values and in international standard units. Output was recorded in kilograms while the input variables: land as recorded in acres; total fertilizers were recorded in kilograms; total chemicals were recorded as total number of acres sprayed. In addition to these input and output variables, socio-economic data of the farms and farmers such as total number of acres at farm, number of acres cultivated with cotton crop, ownership of land, farm machinery/tractors, farmers' age, qualification, experience, and working style was also collected. The socio-economic data have been used to make inferences about cotton farms accordingly.

### Specification of socio-economic factors

#### *Agriculture Farm Type (AFT)*

- Owners – all of the cultivated is owned by the farmer.
- Owner-renters – part of the land cultivated is owned by the farmer himself and part of the land has been taken on rent.
- Renters – all of the land is taken on rent by the farmer.

#### *Agricultural Farm Machinery (AFM)*

- Farmers having their personal tractor and farm machinery.
- Farmers without personal tractors and farm machinery.

#### *Agricultural Farm Size (AFS)*

- Small – farmers having land less than 5 acres.
- Medium – farmers having land 5 to 25 acres.
- Large – farmers having land more than 25 acres.

#### *Farmers' age*

- Young – farmers having age 18 to 30 years.
- Middle aged – farmers having age 31 to 45 years.
- Old aged – farmers having age more than 45 years.

#### *Farmers' qualification*

- Uneducated – farmers having education of 0 or less than 5 years of schooling.
- Basic education – farmers having education of 5 to 9 years.
- High school or college level education – farmers having education of 10 to 12 years.
- University education – farmers having education of 14 or more than 14 years.

**Farmers' experience**

- Less experience – farmers with experience of 0 to 5 years.
- Average experience – farmers with experience of 6 to 20 years.
- Most experienced – farmers having experience of more than 20 years.

**Working style**

- Full time – farmers which work full time are their farms.
- Part time – farmers which work part time at their farms.

**Data Analysis**

In order to see the influences of socio-economic factors on SE, dual analysis had been considered. First, Tobit censored linear regression analysis and secondly, data analysis with reference to estimation of SE of the cotton farms and estimating the effects of socio-economic factors on SE of cotton farms. Three inputs; land (number of acres), total fertilizers, and total chemicals and cotton output were considered to estimate the cotton farms' SE. DEA-Max software has been used to calculate the SE of the data measurement units (DMUs). Finally, Kruskal Wallis and Bonferroni comparison tests have been used to see the effects of socio-economic factors on SE of cotton farms. In the following, methodology used to estimate the SE and testing of influencing factors has been described.

**Estimation of SE of Cotton Farms by DEA**

SE can be input oriented or output oriented which can be considered according to decision making power of the DMUs' actor. In our case, farmer or farm manager is an actor i.e. the decision maker who has control over input(s) but not over output(s) in the concern that he can decide the type and amount of inputs used whereas he do not has much control over the output because agricultural production is depends much and more on natural environment. Therefore, in this study the input oriented SE has been considered. Moreover, in order to consider the return to scale, variable return to scale (VRS) has been considered. For the calculation of SE scores, DEA (non-parametric technique) models have been used and it should be noted that the efficiency scores calculated by DEA model can be 0 to 1. It oriented in seminal works of Debreu (1951), Farrell (1957) and Shephard (1970). DEA uses its basic assumptions to estimate the potential output of the DMU from the output of the most efficient group of DMU's within the sample that are similar to the DMU of interest. In the context of variable returns to scale, DEA seeks for

the most efficient group of DMU's within the sample from those, whose convex combination of input endowments, being equal to that of the DMU of interest, produces not less of each output than the DMU of interest. SE is the ratio of input oriented TE (TE<sup>i</sup>) to output oriented TE (TE<sup>o</sup>). To calculate TE<sup>i</sup>, and TE<sup>o</sup> following models (1 & 2) have been used in this study.

**Model 1: Estimation of TE**

Let us consider:  $x^j = (x_1^j, x_2^j, x_3^j, \dots, x_n^j)$  be the bundle of n inputs used and  $y^j = (y_1^j, y_2^j, y_3^j, \dots, y_m^j)$  be the bundle of m outputs, produced by farm j (j = 1, 2, 3,....., N). Suppose that k is the observed farms and we want to measure the TE of farm 'k'. The observed input-output bundle of farm 'k' is  $(x^k, y^k)$ . Then the correspondent mathematical (algebraic) formula for TE will be:

$$\begin{aligned} \max \phi \\ \sum \lambda_j x_{ij} \leq x_{ik} \quad (i = 1, 2, \dots, n); J = 1 \\ \sum \lambda_j y_{rj} \geq \phi y_{rk} \quad (r = 1, 2, \dots, m); J = 1 \\ \sum \lambda_j = 1; \lambda_j \geq 0 \quad (j = 1, 2, \dots, N); \phi \text{ unrestricted}; J = 1 \end{aligned} \quad (1)$$

Hence TE of farm k would be measured by

$$\tau_k = 1/ \phi^* \quad (2)$$

Here  $\lambda$  is the efficiency measure to be calculated for each DMU j,  $\phi$  is TE measure and  $\phi^*$  is the optimum solution of the DEA linear programming problem given above.

**Model 2: Estimation of output and input oriented TE**

It would be better to define the production possibility set constructed from the sample data set  $D = \{(x^j, y^j) ; j= 1, 2, 3, \dots, N\}$ . The sample estimate of the underlying production possibility set 'S' is:

$$\begin{aligned} S = \{(x, y) : x \geq \sum_{j=1}^N \lambda_j x_j; y \leq \sum_{j=1}^N \lambda_j y_j; \sum_{j=1}^N \lambda_j = 1; \\ \lambda_j \geq 0 (j = 1, 2, 3, \dots, N)\} \end{aligned} \quad (3)$$

After estimation of the TE of farm, a measure of output oriented TE (TE<sup>o</sup>) of a firm with observed input and output bundle  $(x^k, y^k)$  is:

$$\tau_k^o = 1/ \phi^* \quad \text{where } \phi^* = \max \phi : (x^k, \phi y^k) \in S \quad (4)$$

The above model gives the TE<sup>o</sup> in the output oriented context.

When the input conservation is regarded as more important than expanding the outputs, the appropriate measure of performance of firm 'k' would be its input oriented TE (TE<sup>i</sup>):

$$\tau_k^i = \theta^* = \min \theta : (\theta x^k, y^k) \in S \quad (5)$$

TE<sup>i</sup> can be then presented through the mathematical (algebraic) as:  $\min \theta$ , s.t.

$$\begin{aligned} \sum \lambda_j x_{ij} &\leq \theta x_{ik} & (i = 1, 2, \dots, n); J = 1 \\ \sum \lambda_j y_{rj} &\geq y_{rk} & (r = 1, 2, \dots, m); J = 1 \\ \sum \lambda_j &= 1; \lambda_j \geq 0 & (j = 1, 2, \dots, N); \theta \text{ unrestricted}; J = 1 \end{aligned} \quad (6)$$

Here  $\theta$  denotes the efficiency measure in input oriented context.

### Determination of effects of socio-economic factors on se of cotton farms

After estimating the SE scores, our next task is to determine the influences of different factors on SE. While selecting a test for analysis the important questions might be; what is study hypothesis? What types of data are being measured? The data used in the test can be nominal, categorical, ordinal, quantitative discrete, quantitative non-normal, or quantitative normal. Therefore, depending on the data types, different tests can be selected. For example the Kruskal-Wallis is non-parametric test which can be used for comparing ordinal or non-normal variable for more than two groups. Similarly, one way analysis of variance is a test/technique which is used to compare the normally distributed variables for more than two groups and this test is the parametric equivalent of Kruskal-Wallis test. Moreover, regression analysis such as Tobit censored linear regression model can also be used to estimate the influences of socio-economic factors. According to McDonald (2013), Kruskal-Wallis test can be used for nominal variable and measurement variable that is severely non-normal or one variable is nominal and one is ranked variable. In this study, non-normal as well as ranked data have been used. Therefore, Kruskal-Wallis test is the best one for analysis in this study. Moreover, Bonferroni comparison test is best one when one has to compare the groups which are more than two in number and it compares each pair. Therefore, Bonferroni comparison test also has been used to compare the pairs of the ranks. Additionally, to make a comparison based on parametric and non-parametric techniques, Tobit censored linear regression analysis also has been considered.

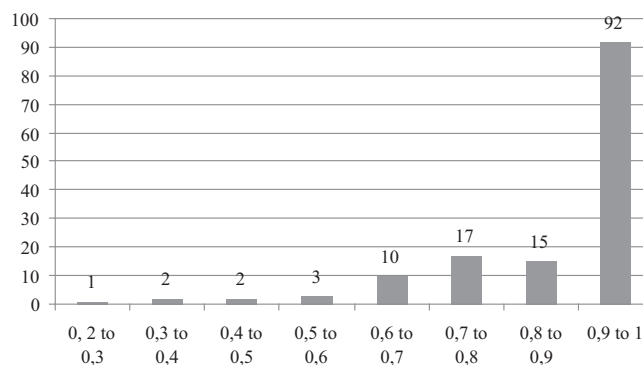
## Results and Discussion

In the following, descriptive statistics and frequency distribution of SE are given and then the influences of the socio-economic factors on the SE of cotton farms are described. The Table 1 shows the descriptive statistics, according to which 142 cotton farms which were included in this study have mean SE as 0.881 with a standard deviation as 0.15. The maximum SE score was estimated as '1' and minimum SE score as 0.286.

**Table 1**  
**Descriptive Statistics of SE of Cotton Farms**

|                          |        |
|--------------------------|--------|
| Mean                     | 0.881  |
| Standard Error           | 0.013  |
| Median                   | 0.947  |
| Standard Deviation       | 0.15   |
| Sample Variance          | 0.022  |
| Kurtosis                 | 2.862  |
| Skewness                 | -1.738 |
| Range                    | 0.714  |
| Minimum                  | 0.286  |
| Maximum                  | 1      |
| Count                    | 142    |
| Confidence Level (95.0%) | 0.025  |

The Figure 1 explains the frequency distribution of SE of cotton farms. The maximum number of farms (i.e. 92 farms) achieved the SE in the range of 0.9 to 1.0. It shows that on the average, cotton farms have better efficiency as the mean SE is high and a few farms fall in the smaller ranges of efficiency scores.



**Fig. 1. Histogram of scale efficiency of cotton farms**

In order to see the influences of socio-economic factors on SE, dual analysis had been considered. Table 2 shows the analysis by considering the Tobit censored linear regression analysis according to which farm size, farmers' age, qualification and experience have a positive effects on the SE as the coefficients of all of the variables are positive but according to the values of 't' and its 'p' values, such influences are statistically, insignificant. Similar is the case with farm machinery (denoted by D1) i.e. it has positive influences but it is statistically, not significant. On the other hand farm working style influences significantly. Part time working farmers (denoted by D2) have negative influences on the SE of cotton farms as the value of coefficient is negative. With reference to farm

**Table 2**  
**Analysis Influence of Socio-Economic Factors by Tobit Regression**

| Tobit Scale Efficiency Farm Size Age Qualification Experience D1 D2 D31 D32, II |           |           |        |       |                            |           |
|---|-----------|-----------|--------|-------|----------------------------|-----------|
| Tobit regression  |           |           |        |       | Number of Obs. =           | 142       |
|   |           |           |        |       | LR Chi <sup>2</sup> (8) =  | 11.92     |
|   |           |           |        |       | Prob. > Chi <sup>2</sup> = | 0.1546    |
| Log likelihood = 71.239442  |           |           |        |       | Pseudo R <sup>2</sup> =    | -0.0913   |
| Scale Efficiency  | Coef.     | Std. Err. | t      | P>t   | [95% Conf. Interval]       |           |
| Farm Size   | .0003522  | .0017201  | 0.20   | 0.838 | -.0030499                  | .0037544  |
| Age   | .0006299  | .0030805  | 0.20   | 0.838 | -.0054628                  | .0067226  |
| Qualification   | .0027981  | .0031999  | 0.87   | 0.383 | -.0035308                  | .009127   |
| Experience  | .0000592  | .0032595  | 0.02   | 0.986 | -.0063876                  | .006506   |
| D1  | .0037473  | .0347386  | 0.11   | 0.914 | -.0649595                  | .0724542  |
| D2  | -.1442231 | .0550247  | -2.62  | 0.010 | -.2530525                  | -.0353938 |
| D31   | .0328135  | .0354541  | 0.93   | 0.356 | -.0373085                  | .1029355  |
| D32   | .0877359  | .0430736  | 2.04   | 0.044 | .0025437                   | .172928   |
| _cons   | .8240794  | .0758798  | 10.860 | .000  | .6740023                   | .9741565  |
| /sigma  | .1440144  | .0086013  |        |       | .1270025                   | .1610263  |

Obs. summary: 1 left-censored observation at Scale Efficiency<=.28600001  
141 uncensored observations  
0 right-censored observations

**Table 3**  
**Socio-Economic Factors and its Influences on SE of Cotton Farms**

| Factors                | Type/Levels                             | Kruskal Wallis Test |         |                |                       | Bonferroni Comparison Test |       |
|------------------------|---|---------------------|---------|----------------|-----------------------|----------------------------|-------|
|                        |   | Farms               | Mean SE | χ <sup>2</sup> | Prob > χ <sup>2</sup> | Differences                | Prob. |
| Farm type              | Owner                                   | 104                 | 0.868   | 3.815          | 0.148                 | 0.027 (1.2)                | 1     |
|                        | Owner-Renter                            | 24                  | 0.895   |                |                       | 0.085 (1.3)                | 0.139 |
|                        | Renter                                  | 14                  | 0.953   |                |                       | 0.058 (2.3)                | 0.746 |
| Farm machinery         | Farms without Tractors                  | 104                 | 0.875   | 0.269          | 0.604                 | 0.023 (1.2)                | 0.431 |
|                        | Farms with Tractors                     | 38                  | 0.897   |                |                       |                            |       |
| Farm size              | Small                                   | 43                  | 0.766   | 38.986         | 0                     | 0.177 (1.2)                | 0     |
|                        | Medium                                  | 89                  | 0.943   |                |                       | 0.055 (1.3)                | 0.651 |
|                        | Large                                   | 10                  | 0.821   |                |                       | -0.122 (2.3)               | 0.013 |
| Farmers' age           | 18 to 30 Years                          | 34                  | 0.89    | 1.679          | 0.432                 | -0.020 (1.2)               | 1     |
|                        | 31 to 45 Years                          | 80                  | 0.871   |                |                       | 0.006 (1.3)                | 1     |
|                        | 46 to 65 Years                          | 28                  | 0.897   |                |                       | 0.026 (2.3)                | 1     |
| Farmers' qualification | Uneducated                              | 22                  | 0.886   | 2.163          | 0.539                 | -0.004 (1.2)               | 1     |
|                        | Basic Level Education                   | 67                  | 0.881   |                |                       | -0.016 (1.3)               | 1     |
|                        | High School or Colledge Level Education | 43                  | 0.87    |                |                       | 0.025 (1.4)                | 1     |
|                        | University Education                    | 10                  | 0.911   |                |                       | -0.012 (2.3)               | 1     |
|                        | -                                       | -                   | -       |                |                       | 0.030 (2.4)                | 1     |
| Farmers' experience    | 0 to 5 years                            | 8                   | 0.864   | 2.618          | 0.27                  | 0.041 (3.4)                | 1     |
|                        | 6 to 20 years                           | 82                  | 0.869   |                |                       | 0.005 (1.2)                | 1     |
|                        | More than 20 years                      | 52                  | 0.902   |                |                       | 0.038 (1.3)                | 1     |
| Working Style          | Full Time                               | 134                 | 0.889   | 2.17           | 0.141                 | 0.033 (2.3)                | 0.668 |
|                        | Part Time                               | 8                   | 0.748   |                |                       | 0.140 (1.2)                | 0.01  |

type, owner-renters (denoted by D31) and renters (denoted by D32) are better efficient as compared to owners. The values of coefficients of each of the D31 & D32 are positive but only renter farms influence statistically, significantly.

The test results given in Table 2, do not explain the objectives clearly i.e. it does not explain the categorical analysis of farm size, age, qualification, and experience of the farmers. In order to see inferences of socio-economic factors categorically, first SE was estimated by using the models (1 & 2) and then Kruskal Wallis and Bonferroni comparison test was taken. The results are shown in Table 3. By comparing the results of Table 2 and Table 3, there are big differences in the significance level such as farm size according to Kruskal Wallis test influences significantly where its effect, in case of Tobit regression analysis, is statistically insignificant. Moreover, all of the socio-economic factors can be categorized, and for categorical analysis, Kruskal Wallis (non-parametric test) is considered as better than the regression (parametric) analysis. Therefore, in the preceding sections results and discussion are based on the estimation of SE and Kruskal Wallis and Bonferroni comparison tests.

#### ***Effects of AFT on SE of cotton farms***

In case of AFT, the results indicated that renters farms have maximum mean SE score as 0.953 while owners have minimum mean SE score as 0.868, while owner-renters achieved mean SE score as 0.895. The  $\chi^2$  value was calculated as 3.815 with prob.  $> \chi^2$  as 0.148 i.e. the differences among groups are not much larger and it is statistically, insignificant. According to Bonferroni comparison test results, maximum difference was found between mean of owners & renters as 0.085 with p value as 0.139 i.e. difference between the two is too small to be statistically significant. The minimum difference between means was found between owners & owner-renters as 0.027 with p value as 1.000 i.e. the differences are statistically not significant. On the other hand, difference between mean of owner-renters & renters was found as 0.058 with p value as 0.746 indicating that difference is statistically insignificant too.

Hence, AFT based on ownership of farm had a negative but linear effect on the SE i.e. the renters are scale wise more efficient than the owners. Conceptually, the logic behind such results is that, in the study area, the renters are mostly those farmers which like agriculture farming and their liking is derived from their personal and family labour. Therefore, in order to get their family and themselves employed, farmers having no or few acres of land get more land from the land lords on rent. Such farmers are very enthusiastic for agriculture farming and they work very hard, hence, get more production constituting higher efficiency.

#### ***Effects of AFM on SE of cotton farms***

According to the results in Table 3, AFM influences positively on SE as the mean SE score of farmers having personal AFM was calculated as 0.897, higher than the mean SE score (0.875) of the farmers which do not have tractors. But the Kruskal Wallis test results indicated that difference between the mean of groups is, statistically, not significant as the  $\chi^2$  value was 0.269 with prob.  $> \chi^2$  as 0.604. Hence, farmers having AFM on rent are lesser efficient as compared to the farmers who have personal tractors. Conceptually, use of AFM may help the farmers for time bound operations like seed sowing, planting especially in rain fed areas where the operations were required to be completed in a short span of time while the rain has been occurred and for harvesting and threshing, as well as for non-repetitive works such as land reclamation, levelling, terracing, eradication of wild-shrubs & perennial weeds. The farm mechanization which has direct link with the use of AFM may lead to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labour and it may also increase agriculture production and profitability on account of timeliness of operation, better quality of work and more efficient utilization of inputs.

#### ***Effects of AFS on SE of cotton farms***

Farm size had significant influence on the SE of cotton farms. It is very clear from the results that medium size cotton farms got maximum mean SE score as 0.943 and small cotton farms got minimum mean SE score as 0.766 while large cotton farms got mean SE score as 0.821. According to the results of Kruskal Wallis test, the  $\chi^2$  value was calculated as 38.986 with prob.  $> \chi^2$  as 0.000, i.e. size of the cotton farm influenced significantly on SE. According to Bonferroni comparison test, the maximum difference was found between small and medium size farms i.e. a difference of 0.177 with p value as 0.000, which is statistically, very significant. Similarly, the difference between medium and large cotton farms is also bigger (i.e. -0.122) and it is statistically, significant too as the p value was found as 0.013. On other hand, difference between small and large cotton farms' SE mean was 0.055 with p value as 0.651, indicating that this difference is statistically not significant. With reference to AFS, results found in this study are very similar as discussed by Odoul et al. (2006) i.e. according to author; scale inefficiency was found to account for a larger share of technical inefficiency on small farms than medium and large farms in the district Embu, Kynia. On the other hand our results are different than the results found by Kiani (2008). According to Kiani, small farms are more efficient because of self-labour and larger farms are more ef-

efficient due to better use of farm machinery and technology while medium farms are inefficient due to less labour and less use of farm machinery.

#### ***Effects of farmers' age on SE of cotton farm***

As per results of the study, farmers' age, did not influence the SE of cotton farms significantly. There are very small differences among mean SE scores of the three groups. The middle aged farmers got lesser mean SE score as 0.871 than the mean SE score (0.890) of young farmers, whereas old aged farmers got the maximum mean SE score as 0.897 while  $\chi^2$  value was found as 1.679 with prob.  $> \chi^2$  as 0.432. Hence, age of the farmers, in this study, showed a non-linear and statistically insignificant relationship with the cotton farms' SE. However, old farmers are the best one as they have maximum mean SE score. On the other hand, middle age farmers got the lowest efficiency, so, it is difficult to get some clear inferences.

#### ***Effects of farmers' qualification on SE of cotton farms***

Like the age, farmers' qualification too influenced the SE of cotton farms, insignificantly. Although the farmers with university education have the highest mean SE score (i.e. 0.911) but the farmers with basic education and the farmers with high school or college level education got mean SE scores (i.e. 0.881 & 0.870, respectively) lesser than the uneducated farmers. The uneducated farmers got mean SE score as 0.886. The  $\chi^2$  value was calculated as 2.163 with prob.  $> \chi^2$  as 0.539 which shows that the differences among mean of SE of cotton farmers' groups is, statistically, insignificant. So, farmers' qualification had a non-linear and statistically insignificant relationship with the SE of cotton farms i.e. first declining and then inclining at higher education levels. Lockheed, Jamison and Lau (1980) pointed out that the effects of education are much more likely to be positive in modern agriculture environments than in traditional ones. Hence, our results also support to such studies i.e. the effectiveness of education is enhanced in a modernizing environment. As a matter of fact, education enhances the decision making capabilities of the farmers.

#### ***Effects of farmers' experience on SE of cotton farms***

The mean SE scores given in the Table 3, indicate that the experience had some positive effect on SE of cotton farms but this effect is too smaller to be statistically, significant. However, maximum mean SE score was gained by highly experienced farmers as 0.902 and minimum by low experienced farmers as 0.864 while middle experienced farmers gained mean SE score as 0.869. The  $\chi^2$

value was calculated as 2.618 with prob.  $> \chi^2$  as 0.270, indicating that difference among mean of cotton farmers based on experience is, statistically, insignificant. According to Bonferroni comparison test, maximum difference was found between the low and highly experienced farmers as 0.038 with p value as 1.000 and minimum difference was found between the low and middle experienced farmers as 0.003 with p value as 1.000 while the difference between the middle and highly experienced farmers was found as 0.035 with p value as 0.668, indicating that no significant difference exists between any pair of the cotton farmers' groups based on their experience. However, the experience which is the counterpart of age and it influences the SE of cotton farms positively, can be also observed from the influences of age. The older farmers are more experienced and get benefit of their knowledge to use inputs more efficiently.

#### ***Effects of farmers' working style on SE of cotton farms***

According to the Kruskal Wallis test results, the  $\chi^2$  value was calculated as 2.170 with prob.  $> \chi^2$  as 0.141, indicating that the difference is statistically, insignificant. However, maximum mean SE score was achieved by farmers working as full time as 0.889 and by farmers working as part time was 0.748. On the other hand, according to Bonferroni comparison test, a difference of 0.140 with p value as 0.010 was found between the two groups, indicating a significant difference between the two groups. Although, according to Kruskal Wallis test, the working behavior of the farmers influences the SE of cotton farms insignificantly, but the difference between the means of the two groups is larger and it is, according to Bonferroni test, significant too. Hence, the farmers working as full time were, scale wise, more efficient than the farmers working as part time. Conceptually, the full time working farmers may give more attention towards their corps and therefore, got better production.

## **Conclusion**

It was concluded that scale efficiency is, statistically, significantly influenced by the socio-economic factors; farm size and farmers working style. It was found that the medium size cotton farms i.e. farmers having cotton cultivated on 6 to 25 acres of land are scale wise the most efficient whereas, small farmers as well as large farmers are less efficient. A big difference was found between the owners and renters' cotton farms i.e. renters' cotton farms have better SE as compared to owners' farms. Agricul-



tural farm machinery showed a positive but very small effect on SE of cotton farms. It was also found that the social factors influence the scale efficiency of cotton farmers, statistically, insignificantly. However, old aged farmers are more efficient than the young farmers; farmers having university education are more efficient than the other levels; most experienced farms are the most efficient and least experienced farmers are least efficient; and full time working farmers are more efficient than the part time working farmers. This study also concludes that the farmers and the policy makers can focus these factors and may react accordingly so that the efficiency as well as the production of the cotton farming may be enhanced.

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