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Measuring Technical Efficiency among Maize Farmers in Kenya's Bread Basket

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Abstract: Maize production is the major farming activities in Kenya's agriculture which need more attention to improve productivity to meet the domestic demand. This study therefore, examined the efficiency of different categories of maize farmers using the survey data obtained from a sample of 540 farmers who were selected randomly. The data was analyzed using the stochastic frontier and data envelopment analysis. The results indicate that the overall mean technical efficiency for maize farmers is 85%. However, there are farmers who have technical efficiency that is as low as 56%. Considering the performance of different category of farmers, the result revealed that the mean technical efficiency of 95, 83 and 80% for large, medium and small scale farmers, respectively. This suggests that the large scale farmers exhibit a higher degree of technical efficiency levels than medium and small scale counterpart. This indicates that there is higher scope to increase the profitability within small and medium scale farmers than large scale farmers through improving efficiency.

Key words: Data envelope analysis, maize production, farmer's categories, efficiency level, agriculture, Kenya

INTRODUCTION

Even though, maize is the most important crops in Kenya and provide an important source of rural household income, its production has declined over the years (Nyoro *et al*., 2001; Republic of Kenya, 2003) and resulting in rural Kenya income exhibiting a steep downward trend (Argwings-Kodhek *et al*., 2001; Republic of Kenya, 2004). The annual consumption of maize is estimated at about 3060 thousands ton but its production varies between 1494 and 3132 thousands ton depending on the prevailing weather and producer price. Thus to meet the deficit, the country continues to depend on imports (Republic of Kenya, 2000, 2004).

To meet this growing demand and achieve self-sufficiency, the current growth rates for maize should be doubled through increased productivity of the existing limited resource. This growing demand made the country increasingly dependent on imports (Nyangito *et al*., 2004). Over dependence on imports is likely to displace the only livelihood of the local population. Thus, it is not an appropriate means of achieving food security because it will affect the domestic production for both food and exports (Nyoro *et al*., 2001; Argwings-Kodhek *et al*., 2001). The study area is basically an agricultural district which comprise what is known as bread bakst of Kenya producing the largest portion of maize in the country. However, the performance of maize in this region has dropped substantially, exposing the country to great risk of food shortage which will lead to starvation of many households in the near future (Kisaka *et al*., 2001). Therefore, the main questions that need to be addressed are; why such lower productivity in maize farming? Are the farm inputs utilized effectively and do farmers attain the optimum yield? These critical issues call for urgent closer examination of current production system. Thus, it is imperative that the performance of farmers has to be assessed in order to find out ways and means of improving maize productivity. Given the limited arable land area, the country will have to rely relatively more on improving farmers' performance than area expansion for future increases in maize production.

Therefore, it is necessary to understand the current production system, discover the level of farmer's performance, identify factors that affect the yield and devise strategies to improve their performance. Thus, the objective of this study was to estimate the technical efficiency of different categories of maize farmers and to compare the performances among different group of farmers.

MATERIALS AND METHODS

Study area: The study was conducted in one of what is know as Kenya's bread basket district and that is Uasin Gishu district in Rift valley province, Kenya. It extends between longitudes 34°50' and 34°57' East and latitude of 0°3' South to 0°1' North. Both primary and secondary data were used to get the necessary information needed to achieve the objective of the study. The population for this survey involved all maize farmers in Uasin-Gishu district. The farmers were categorized as small, medium and large

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scale on the basis of the farm size they cultivated. For the purpose of this study, a small-scale farmer was taken to be a farm household owning 20 acres of land or less, medium-scale were those with 21-49 acres and large scale were those who have >50 acres. To get the required sample size, the multi-stage random sampling procedure was used and a total of 540 farmers were sampled and interviewed.

Data analysis: The study employed Data Envelopment Analysis Models as analytical tools in data analysis. The empirical model specification used are:

Data envelope analysis: The technical efficiencies were calculated using input-oriented Data Envelopment Analysis (DEA) approach with the assumption of Variable Return to Scales (VRS). Since, farmers usually have more control over their inputs than their outputs, the present study used the input-oriented DEA Model with Variable Return to Scale (VRS) Technology. The envelopment form of the input-oriented VRS DEA Model is specified as follows:

Minimise θ:

$$\theta, \lambda \quad (1)$$

Subject to:

$$-y_i + Y\lambda \geq 0 \quad (2)$$

$$\theta x_i - X\lambda \geq 0 \quad (3)$$

$$N1' \times \lambda = 1 \quad (4)$$

$$\lambda \geq 0 \quad (5)$$

where, θ_i is the scalar which measures the technical efficiency of the ith farmer and $(1-\theta_i)$ measures the technical inefficiency of the ith farmer. The θ_i can have any value between 0 and 1; a value of one indicates that the farmer is on the frontier and 100% technical efficient and a value of <1 indicating that the farm is technically inefficient and it can reduce all its inputs by at least $(1 - \theta_i)\times 100\%$ without affecting the output (Singh *et al*., 2000; Jaforullah, 2003; Lissitsa *et al*., 2005).

RESULTS AND DISCUSSION

Efficiency plays a significant role in increasing maize farmers gain. Using the Stochastic Frontier Analysis (SFA) Model, the coefficient of the variables, the parameter σ^2 and γ are estimated. The parameter σ^2 is the sum of u and v $(\sigma_u^2 + \sigma_v^2)$ and the parameter γ is the ratio of the variance of u to the sum of the variance of u and v (σ_u^2/σ^2). It was found that the estimates of these parameters are significant at 1% level of significance (Table 1).

The fact that gamma (γ) is significantly different from zero implies that the effect of technical inefficiency plays an important role in the variation of observed maize output. The mean estimated values of gamma (γ) were 0.88. This implies that on average 88% of total variation in maize output is due to technical inefficiency. This result is consistent with results reported by Sharma *et al*. (1999), Binam *et al*. (2004) and Shanmugam (2003).

The estimated values of gamma (γ) for each category (Table 1) indicate that 97, 99 and 69% of the total variation in maize output is due to technical inefficiency within large, medium and small scale maize farmers, respectively. According to the analysis results, the overall technical efficiency of sample respondents ranges from 66-100% with a mean of 85% (Table 2). These figures suggest that on average, maize growers in Kenya are producing at about 85% of their potential output level, given the present state of technology and input levels.

Large scale farmer: The mean technical efficiency for large scale maize farmers was found to be 94% within a range of 84-100%. This finding confirm to a similar finding by Sharma *et al*. (1999). However, it had showed a higher mean technical efficiency level than the one reported by Shanmugam (2003). These figures indicate that on an average, the output actually produced by large scale

Table 1: Maximum likelihood estimates of parameters in maize production

	Large scale farmers		Medium scale farmers		Small scale farmers	
Independent variables	Coefficients (β_j)	t-ratio	Coefficients (β_j)	t-ratio	Coefficients (β_j)	t-ratio
Constant	3.184	1.688*	0.358	0.348	2.745	6.441**
LnX_1 (value of tractor)	-0.108	0.496	0.510	5.268**	0.004	0.264
LnX_2 (labour)	0.168	1.770*	0.337	3.705**	0.141	2.078**
LnX_3 (fertilizer)	0.578	4.290**	0.206	2.903**	0.303	6.036**
LnX_4 (pesticide)	0.055	4.184**	0.010	1.632*	-0.009	1.225
LnX_5 (seed)	-0.278	0.867	-1.116	3.872**	-0.163	1.203
Sigma-squared (σ^2)	0.175	3.417**	0.201	7.016**	0.146	5.534**
Gamma (γ)	0.970	0.059	0.997	316.173	0.696	5.706**
Log likelihood	1.910	-	4.007	-	43.500	-
LR (Likelihood Ratio)	8.550	-	18.227	-	4.250	-

**Significant at 1% level; *Significant at 5% level; β_i is the coefficients of the variable i where (i = 0, 1, 2, 0.5)

Table 2: Minimum, maximum and mean technical efficiencies for maize farmers

Categories	Minimum	Maximum	Mean
Large scale	0.84	1.0	0.94
Medium scale	0.58	1.0	0.83
small scale	0.57	1.0	0.80
Over all	0.66	1.0	0.85

Own field survey, 2009/2010

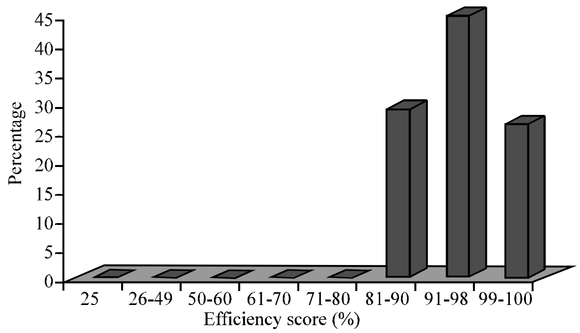

Fig. 1: Distribution of technical efficiency scores within large scale maize farmers

farmers was 94% of the best practice output. The majority of large scale maize farmers (45%) have achieved technical efficiency levels that fall within ranges of 91-98% (28%) followed by those who achieved the efficiency levels that fall within 81-90%. The highest efficiency level in this category, fall within the range of 98-100% which constitutes about 26% (Fig. 1). In general, the efficiency estimate results indicate that >29% of the large scale maize farmers have an efficiency level below the average farmer performance in the sample.

For those farmers who (26%) have achieved full technical efficiency level, no significant improvements in productivity gain through improving technical efficiency. However, the results indicated that a good percentage of the large scale maize farmers had a technical efficiency levels below the average farmer in the sample, suggesting that there is room for increasing maize output given the available resources or they can increase their profit by reducing the current level of inputs while maintaining the same level of output. The above figures suggest that if the average farmer in the sample was to achieve the Technical Efficiency (TE) level of its most efficient counterpart then the average farmer could reduce the input use by 6% [1 - (94/100)]. A similar calculation for the most technically inefficient farmers reveals inputs savings of 16% [1 - (84/100)]. In view of the above facts, it is advisable to develop a strategy and policy to motivate the inefficient farmers to achieve full efficiency level and also introducing new technology to increase gain for those who achieved full technical efficiency. For better explanation, the graph of the relationship between the percentages of farmers and the efficiency scores is shown in Fig. 1.

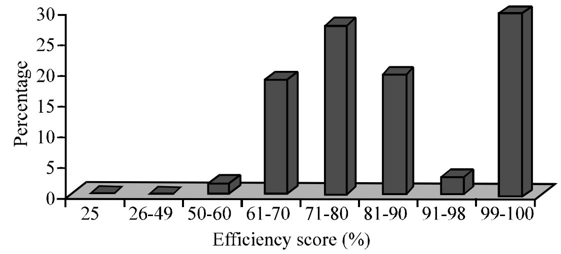

Fig. 2: Technical efficiency scores among medium scale maize farmers

Medium scale farmers: Technical Efficiency (TE) scores within the medium scale maize farmers vary from 58-100% with a mean of 83% (Table 2). The estimated mean technical efficiency implies that on average, the sample farmers tend to realize only 83% of their technical abilities. This result is very close to the finding of Shanmugam (2003). The result indicates that the majority of the medium scale maize farmers (29.4%) have attained a technical efficiency levels of 98% and above followed by those who achieved an efficiency level between 91-98% which accounts for only 3%. About 19.6% of them achieved a technical efficiency level of between 81 and 90% while 27.5% of them have attained an efficiency level between 71-80%. This result indicates that the poor performing (inefficient) farmers of this group constitute about 20.6% having technical efficiency levels that fall <70%, suggesting that they are on average inefficient. However, some of the medium scale maize farmers are operating at full technical efficiency level. Thus, development and adaptation of new technology may be a key to raise the productivity of such farmers.

According to the finding if the average farmers in the sample were to attain the technical efficiency level of its most efficient counterpart, the average farmer could realize 17% inputs reduction [1 - (83/100)] and the most technically inefficient farmer in the sample to achieve the level of technical efficiency which is the same as the star performing farmer in the sample, the inefficient farmers could reduced their input up to 42% [1 - (58/100)]. To give a better indication of the distribution of technical efficiencies, the distributions of the estimated technical efficiency scores are shown in Fig. 2. The distribution of technical efficiency levels indicates that the distribution is irregular implying that the degree of variability in efficiency scores is wider within the medium scale farmers. Thus, potential overall input reduction can be achieved if all of them operate at full technically efficiency level.

Small scale farmer: The estimated technical efficiency scores for small scale maize farmers vary between 57 and 100% with a mean of 80% (Table 2). The mean technical efficiency of this category of farmers is consistent with the study by Dey *et al*. (2000). These figures suggest that on an average the small scale maize farmers achieved only 80% of their potential ability. The technical efficiency scores for small scale farmers indicate that majority of them (40.4%) have achieved a technical efficiency level between 71 and 80%. About 13.5% of them had an efficiency level within the range of 61-70% and a few of them had an efficiency level between 51-60%.

About 28.7% of them have an efficiency level between 81-90% while those who attained the highest efficiency level accounts for only 11.3%. According to estimate, 55% of the small scale maize farmers performed around or below the sample average. This indicates that there is great potential to improve output among the small scale maize farmers, given the current technology and available inputs or there is higher possibility of minimizing cost by reducing the current input level while producing the same output, through achieving the full technical efficiency level. These results suggest that if the most technically inefficient farmer in the sample was to achieve the technical efficiency level similar to the most efficient farmer in the sample, the inefficient farmer could have reduced his total input use by 43% [1 - (57/100)]. Similarly if the average farmers in the sample were to reach to the technical efficiency level of its most efficient counterpart, the average farmers could gain an input reduction of 20% [1 - (80/100)]. Figure 3 shows the distributions of the estimated efficiencies. The distribution of estimated technical efficiency scores shows that most of them concentrated around the mean indicating that most of them are not technically efficient, suggesting more room for productive gain.

Comparison of technical efficiency among maize farmers: The efficiency analysis revealed that the estimated mean Technical Efficiency (TE) value for large scale maize farmers is much higher than medium and small

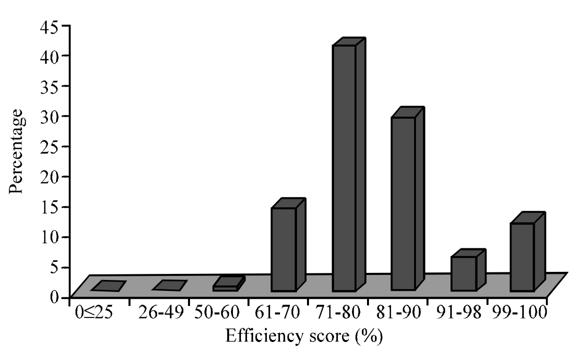

Fig. 3: The distribution of technical efficiency score within small scale maize farmers

scale farmers. However, there is little difference in mean technical efficiency between the small scale and medium scale maize farmers. It was also found that the number of farmers who achieved high technical efficiency level is greater within large scale than small and medium scale farmers. Moreover, the least technical efficiency levels within the large scale farmers lie >81% whereas within the small and medium scale farmers it falls between 51 and 60%. In view of the above, evidences we can conclude that large scale maize farmers relatively perform better than medium and small scale farmers indicating that on average the potential total input saving is greater within medium and small scale farmers than large scale farmers. This suggests that there is high possibility of productive gain within small and medium scale maize farmers and therefore, presents a relatively greater scope for improvement.

The better performance within the large scale maize farmers may be attributed to better management practice, access to inputs and access to institutions that help in improving productivity. In addition, large scale farmers are business oriented. Thus, they put more efforts to get more profit. Therefore, the results suggest that more effort has to be directed towards the medium and small scale maize farmers to encourage them to improve their input use or combination of inputs which leads to the achievement of full technical efficiency. Mizala *et al*. (2000) stated that those farmers who achieved efficiency level below the average can be classified as both inefficient and ineffective. Even those who achieved above the average results would do better if they made full use of their potential given the inputs available to them. Thus, they should be encouraged, motivated and educated to become more efficient. Therefore, the government's efforts to improve the technical efficiency of the maize growers should be directed more at medium and small scale farmers as they have lower technical efficiency than the large scale farmers. On the other hand to improve the productivity of those farmers who have achieved full technical efficiency level, development and adoption of new technology may be a key to raising the productivity.

CONCLUSION

Even though, the results of the study give considerable evidences that in all categories of maize production the observed maize output is much less than its respective potential outputs, indicating that there is high possibility of substantial input saving in maize production, the large scale farmers performed relatively better than small and medium scale farmers. Thus, there is a high potential to improve productive gain within the small and medium scale maize farmers through improving their technical efficiency.

RECOMMENDATIONS

Therefore, more attention needs to be directed to words encouraging, educating and motivating the small and medium scale farmers. On the other hand, for those farmers who achieved near full technical efficiency there may be a need to develop and introduce a new technology to increase productivity. When inefficiencies arise, it does not only imply sub-optimal allocation of resources but it may also lead to rural income deterioration and farmers' stagnation. Farmers can improve the level of efficiency either by applying a new technique of production such as different combinations of inputs or adopting technological progress. They may accept a new combination of inputs to reduce the total cost of production than adopting the new technology. This is because it is more cost effective to achieve increases in farm output by improving efficiency rather than introducing new technology. Therefore, encouraging more efficient techniques can be regarded as a policy to increase the profitability and to release surplus inputs to be used in the production of an extra amount of either maize or other products. Finally, further research has to be done to identify the possible sources of inefficiencies and magnitudes of their effect in all categories of maize production. This will provide more information for any attempt to improving productive gains.

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