Tropentag 2008
University of Hohenheim, October 7-9, 2008
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Analysis of the Effect of Land Tenure on Technical Efficiency in Smallholder Crop Production in Kenya

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Abstract

Agriculture is the backbone of the Kenyan economy contributing 26% to GDP and 70% to employment. Majority of the farmers in Kenya are smallholder farmers possessing less than 3 acres of land. The agricultural sector in Kenya has been facing several challenges among them declining yields. While the decline in yields could be associated with several other factors, it could also be as a result of the effect of insecure land tenure systems which are little understood. This study examines the technical efficiency of alternative land tenure systems among smallholder farmers and identifying the determinants of inefficiency with the objective of exploring land tenure policies that would enhance efficiency in production. The study is based on the understanding that land tenure alone will not be enough to indicate the levels of efficiency of individual farms, other socio economic factors such as gender, education and farm size would also be expected to be important determinants of efficiency. A stochastic frontier was used to estimate technical efficiency and relate it to land tenure and socio economic factors using data from 22 districts from the main agro–ecological zones.

The study found that parcels with land titles have a higher efficiency level. Other factors such as education status of head, access to fertilizers, and group participation were also found to significantly influence technical efficiency. The study recommends that the process of land registration should be extended to other regions of the country but at the same time other factors such as access to inputs and improvement of education status should also be addressed.

Keywords: Land Tenure, Smallholder, Stochastic Frontier, Technical Efficiency, Kenya

Introduction

Agriculture is the mainstay of most economies in Sub-Saharan Africa (SSA) contributing at least 70 to 80 percent of employment, 40 percent of exports earnings, 30 percent of gross domestic product (GDP) and up to 30 percent of foreign exchange earnings (IFAD, 2002). However, agricultural productivity in Africa has declined over the last two decades leading to progressive increase in food imports (AU/NEPAD 2003). Since 28 percent of the population in SSA suffers chronic food insecurity, efficiency of resources used in agricultural production will continue to be a major concern for policy and initiatives targeting improved livelihoods in the region.

Kenya, like other SSA countries, is heavily dependant on agriculture with over 87% of its population living in rural areas and deriving their livelihoods from agriculture (Nyoro, 2002).

Smallholder farmers account for 75 percent of total agricultural production and 70 percent of marketed agricultural output (Kinyua, 2004). One of the main characteristics of smallholder farming in Kenya is small land sizes averaging 2-3 hectares, making land one of the major constraints limiting increased agricultural production. Land tenure systems operating in Kenya vary and in turn influence land sizes in agricultural production. However it is not clear how land tenure influences efficiency in agricultural production and in particular the technical efficiency of crop production by smallholder farmers, to inform formulation of pro-poor growth strategies.

Methodology

The study applied a stochastic frontier model to estimate technical efficiency using input approach following Amaza and Maurice (2005). The empirical model takes the following general form:

$$Y = f(x_i, \beta)e^{v_i - u_i} \qquad (1)$$

Where Y is the dependent variable, *f(x)* is the functional form, β is the technical coefficient, v_i is the random component which assumed to be identically and independently distributed with mean zero, and u_i is the inefficiency effect of the firm. A Cobb Douglas logarithmic function was adopted resulting in estimation equation (2).

$$\text{vprdlln} = \beta_o + \beta_2 \ln acres + \beta_3 \ln vman + \beta_4 \ln vfert + \beta_5 \ln lp\cos t + \beta_6 lpsd\cos t + \beta_{irrigation} + (V_i - U_i) \qquad (2)$$

Where:

vprdlln	=	Natural Log of total value of farm output measured in Kenya Shillings
lncres	=	Natural log of Land size (acres) of the parcel
lnvman	=	Natural log of cost of manure in kilograms used on the parcel.
lnvfert	=	Natural log of cost of inorganic fertilizer in kilograms used on the parcel
lnlpcost	=	Natural log of cost of land preparation(ksh per acre)
lnsdcost	=	Natural log of cost of seed used (ksh per acre)
Irrigation	=	Dummy variable for main source of water that is used on the parcel of land. irrigated irrigation=1 if rain-fed irrigation =0
$(V_i - U_i)$	=	A composed error term where. V_i: is the random error term (statistical noise) and U_i: represents the technical inefficiency

Study Area and Sampling

Smallholder crop producing farmers in Kenya were sampled from 5 agro-ecological zones with 22 districts. A multi-stage proportional sampling selected 1340 smallholder farmers. The data was collected by Tegemeo Institute, Egerton University.

Results and Discussion

Technical efficiency was estimated as per equation 2 and Maximum Likelihood(ML) method was used. The result of the estimation is presented in Table 1. The model's overall explanatory powers are good with a highly significant log likelihood ratio test ($\rho < 0.001$) indicating that inefficiency exists and is indeed stochastic. All the independent variable except land preparation cost and seed cost are strongly significant at ($\rho < 0.01$). The model has a wald χ^2 (chi square) of 2609.94 therefore rejecting the hypothesis that all the coefficients are jointly zero. Goodness of fit tests for the model was performed using log likelihood ratio tests as described in Hensher et al. (2005). The results of the stochastic frontier model (Table 1) show that most of the independent variables are strongly significant at ($\rho < 0.001$). The coefficients of the independent variables represent the elastisities of production. Ownership of land without title, cost of land preparation and cost of seeds were found to be insignificant.

Table 1: Results of the Stochastic Frontier Model

(Dependent variable = log of the total value (KShs.) of crop produced by the farm)

Variable	Variable Description	Coefficient
lnacres	Natural log of total cultivated land(acres)	0.769*
lnvman	Natural log of value of manure used (ksh per acre)	0.010*
lnvfert	Natural log of the value of fertilizer used (ksh per acre)	0.018*
lnlpcost	Natural log of value of land preparation(ksh per acre)	-0.001
lnsdcost	Natural log of value of seed used (ksh per acre)	0.001
irrigation	Dummy variable for irrigation	0.427*
_cons	Constant	10.569*
RTS	Returns to Scale(sum of coefficients)	1.224
sigma_v		0.627
sigma_u		0.665
Sigma²($\sigma_u^2 + \sigma_v^2$)		0.835
Lambda(σ_u^2 / σ_v^2)		1.060
Wald χ^2 (8)		2609.940
Likelihood-ratio test $\bar{\chi}^2 = 9.6$ P value=0.001		

Note: * Indicate that the coefficients are statistically significant at 1% level,

The returns to scale (RTS) value, 1.224, obtained from the summation of the coefficients of the estimated parameters (elasticities) indicate that farms in the study area are in stage I of the production frontier. Stage I of production is characterized by increasing returns to variable inputs. This indicates that farms in Kenya area at a stage where the marginal returns to variable input is positive *ceteris paribus*. The highly significant ($\rho < 0.001$) sigma_v value = 0.627 indicates that technical inefficiency exists in crop production. The lambda ratio (σ_u^2 / σ_v^2) indicates ratio of the random error effect to the inefficiency effect. If the lambda value is greater than unity, the random error dominates the technical inefficiency effect (U_i). The estimate of the total error variance sigma^2 ($\sigma_u^2 + \sigma_v^2$) = 0.835 implying that 84% of the differences between the observed and the maximum possible production for small-scale crop production households is due to existing differences in the technical efficiency levels among the households.

From the model presented in Table 1, technical efficiency levels for each parcel of land were predicted. In theory, technical efficiency levels ranges between zero and one. The higher the technical efficiency value, the higher the level of technical efficiency of the farm (Coelli, 1994). The efficiency levels in this study were found to range from 0.118 to 0.861 with a mean of 0.632. This implies that if an average parcel of land (farm) is to achieve the efficiency of the most efficient counterpart, then the average farmer could realize up to 27[1] percent more output from the same resources.

In terms of tenure systems, Table 2 presents the technical efficiencies of the three land tenure systems in different agro ecological zones. Central highland zone was found to have the highest efficiency level with a mean of 0.694. An average household in Central Kenya has the potential of producing 19 percent more output given the same set of inputs if it would have to be as efficient as the most efficient farm in the entire study's sample. The most inefficient region is the Eastern and Coastal lowlands with an efficiency level of 0.604 implying that an average farm in this region would have to produce 29.42 percent more output if it has to be as efficient as the most efficient farm in the entire study's sample. The analysis found that among parcel that are held with own titles, Central highlands was the most efficient with an average efficiency level of 0.709. Most households in this zone are smallholder farmers producing high value crops. The least efficient zone was found to be Eastern and Coastal lowlands with a mean efficiency of 0.595.

[1] $\left(1 - \frac{0.632}{0.802}\right) * 100$

Table 2: Average Technical Efficiency by Zone and Tenure System

Agro-regional zones	Land owned with title	Land owned without title	Rented land	Average for Entire zone	Computed F	Critical valve of F
Eastern and coastal lowlands	0.595	0.609	0.572	0.604	*1.70*	*3.00*
Hp maize and w transitional	0.617	0.625	0.602	0.617	*3.25*	*3.00*
Western lowland	0.639	0.628	0.634	0.634	*2.12*	*3.00*
Western highlands	0.665	0.626	0.554	0.620	*9.79*	*3.00*
Central highlands	0.709	0.702	0.625	0.694	*4.7*	*3.00*
All zones	0.643	0.632	0.600	0.631		
F statistic across tenure system					*14.31,*	*3.00*
F statistic across zones					*33.92,*	*2.38*

An *F*-test revealed statistical significant differences (at *P<0.0001*) in mean technical efficiencies across tenure systems ($F_{(2,\ 1635)}=14.31,\ P=0.0000$). This confirms that possession of title has a positive effect on the level of technical efficiency. In order to confirm whether the significant difference exists in all the agro ecological zones, an F test was conducted separately for each zone across the three tenure systems. The results indicated a high significance between tenure and technical efficiency in Central and Western highlands and High Potential Maize zone. In these three zones parcels that are owned with title have higher level of efficiency. This indicates that there is a positive relationship between tenure security and efficiency. The results concur with findings of Pender *et al*. (2004) and Deininger and Jin (2006) who found a strong relationship between tenure security and technical efficiency.

The results presented in Table 3 show that households headed by persons with no formal education have the lowest efficiency level with a mean of 0.615 while those headed by persons with post secondary education have the highest efficiency level with a mean of 0.651. This indicates that there is a positive relationship between education and technical efficiency. Further, education was found to have a significant effect ($F_{(3,\ 1633)}=4.719,\ P=0.016$) on technical efficiencies under the different tenure systems. At primary and secondary levels of the differences in technical efficiency across the tenure systems was found to be significant (Table 3).

Table 3: Average Technical Efficiency for Different levels of Education of Household head

Education level	**Land with title**	**Land without title**	**rented**	**Total**	Computed F	**Critical Value of F(0.05)**
No formal education	0.622	0.617	0.582	0.615	*1.78*	*3.0*
Primary level	0.646	0.635	0.600	0.635	*9.07*	*3.0*
Secondary level	0.655	0.632	0.591	0.634	*7.02*	*3.0*
Post secondary	0.653	0.640	0.668	0.651	*0.43*	*3.09*
F statistic across education levels					*4.719,*	3.0

Access to credit is an important aspect in agricultural development. The table 4 below shows the relationship between credit use and technical efficiency in this study. Households accessing credit either for agricultural or non agricultural use have higher efficiency than those not accessing credit. The mean technical efficiency for households accessing credit is 0.653 while the mean efficiency for those not accessing credit is 0.615. Households who have access to credit and at the same time have titles for their land have a mean technical efficiency of 0.669. However, households with rented land and who have access to credit have a relatively low efficiency level with a mean of 0.60.

Table 4: Average level of Technical Efficiency, Credit Access and Group membership

Tenure	Credit		Group membership	
	With	Without	Members	Non members
Owned with title deed	0.669	0.622	0.651	0.613
Owned without title deed	0.657	0.611	0.637	0.618
Rented	0.600	0.599	0.600	0.598
Total	0.653	0.615	0.638	0.613
T test for credit access	computed t=-6.88*		computed t=-3.77*	

* Critical value=±1.96

Households with at least one person been a member of group have higher technical efficiency with a mean of 0.638. Households with no member participating in group activities have a mean efficiency of 0.613. The efficiency levels of households with at least one person participating in group activities and at the same time owning land with title is higher.

Implications of the Study Findings and Conclusion

This study presents an application of a stochastic frontier function in estimating technical efficiency and relating the efficiency levels to land tenure status among other socio economic characteristics in Kenya. The Key finding of the study is that there is a direct relationship between the tenure status of the farm and technical efficiency. At the same time, tenure augments other farm and socio-economic characteristic such as credit availability and membership to groups in increasing the farm level efficiency. The implication for policy is that land registration is important in increasing the levels of farm efficiency. However, it should not be handled in a isolation from other important aspects such as improvement of access roads, availability of fertilizer and seed, improved education standards and also encourage participation in producer groups.

Acknowledgments

The authors would like to acknowledge Tegemeo Institute, Egerton University for providing the data for this study and facilitating participation in the Tropentag conference.

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