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Technical efficiency and food security of African indigenous vegetable farmers in Kenya

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Introduction

Kenya is rich in African indigenous vegetables (AIVs) with an estimated 210 known species (Pasquini et al., 2009). These vegetables represent an important source of food for households in Sub-Saharan Africa and have been consumed for many years as supplement to diets (Faber et al., 2010). Furthermore, they are also recognized as an important source of income generation and livelihoods for the rural communities, especially for the women (Weinberger et al., 2011) and are considered to be potential as cash crops in the peri-urban areas. Production and sale of AIVs have been found to increase the likelihood of improving poverty levels in Kenya (Gotor and Irungu, 2010). A large number of AIVs are reported to be rich in micronutrients, antioxidants and have health protecting properties and uses (Yang and Keding, 2009).

Until today, food insecurity and poverty remain major problems in Sub-Saharan Africa (Otuska, 2013). It has been noted that over 10 million people suffered from chronic food insecurity and poor nutrition in Kenya in 2011 (GoK, 2011). Increasing food security and income level of farmers are possible through increase in efficiency and productivity of agricultural enterprises (Ogundari, 2014). Despite the immense potential of AIVs as an important source of food, nutrition and income, there is a scarcity of studies on the productivity and efficiency of AIVs and its impact on household income and food security. Using data from rural and peri-urban AIV producing farmers of Kenya, the present study aims to (1) estimate the technical efficiency of AIV producers, (2) identify the factors explaining technical inefficiency, and (3) analyze the impact of technical efficiency on income and food security based on indicators such as Food Consumption Score (FCS) and Household Dietary Diversity Score (HDDS).

Material and Methods

Data for this study comes from the household survey that was carried out in 2014 from rural and peri-urban areas of Kenya. A multistage sampling technique was employed in selecting the farm households. Overall 1232 households were selected; 806 from rural counties and 426 from peri-urban counties. As a survey instrument, pre-tested structured questionnaires were used to collect data through face to face interview. The data set contains detailed information on production activities, particularly the output and inputs of farm activities. The data set also includes standard information concerning household and farm characteristics, marketing, savings and credit and shocks. In addition, the questionnaire asked for extensive information on food security such as the frequency and the varieties of foods consumed during a normal week and also on a worst week during different seasons, food sufficiency to meet family's needs for the whole year and strategies applied to cope when households face food insecurity problems.

The methodology is conducted in two steps. In the first step, technical efficiency was estimated and the factors explaining technical inefficiency were determined using the Stochastic Frontier Model. The basic specification of stochastic frontier model is given as below;

$$Y_i = f(X_i\beta) + v_i - \mu_i \text{ .... (1)}$$

Where, Y_i is the output value
X_i is a vector of input quantities used in production
β is a vector of unknown parameters of the production function

$\{ f(X_i\beta)\}$ is the frontier production function that measures the maximum potential output from a vector of inputs.

The farm-specific technical efficiency (TE_i) of farmer i is estimated using the expectation of μ_i conditional on the random variable ε_i and is expressed as;

$TE_i = \exp(-\mu_i)$, such that, $0 \leq TE_i \leq 1$. A value of 1 represents technically efficient and a value of 0 represents technically inefficient. The inefficiency model is specified as below;

$$u_i = \delta_0 + \sum_{k=1}^{16} \delta_k Z_k \text{ .... (2)}$$

Where, u_i represents the inefficiency score of each household obtained from equation (1)
Z_k represent variables that may influence farmer´s inefficiency

Using Propensity Score Matching (PSM) as given in equation 3, the second step analyzed the impact of technical efficiency on different indicators such as household income, FCS and HDDS.

$$ATT = E(Y_1\backslash T = 1, X) - E(Y_0\backslash T = 0, X) \text{ .... (3)}$$

Results and Discussion

Distribution of technical efficiency scores

The results of efficiency analysis reveal that none of the farmers have technical efficiency of 1, indicating that farmers are producing AIVs below the maximum efficiency frontier. Most efficient producer has an efficiency score of 0.68 and the least efficient has a score of 0.004. The mean value of technical efficiency is 0.28. This implies that there is substantial technical inefficiency and in principle, farmers could achieve 72% higher production on average using the same mix of production inputs.

Factors influencing technical efficiency

Table 1 represents the estimation results of technical efficiency effects. It is to be noted that a negative sign on a coefficient means that variables have a positive effect on technical efficiency. Risk attitude is negatively associated with technical inefficiency for AIV producers. It indicates that higher the risk taking behavior the more technically efficient farmers are**.** Furthermore, savings increase technical efficiency of AIV producing farmers which can be explained with timely availability of inputs needed for cultivation of crops. Peri-urban area has a negative influence on technical inefficiency. The significant and negative coefficient shows that AIV producers residing in peri-urban areas have higher technical efficiency compared to those living in rural areas. This underscores the significant contribution that peri-urban region provide farmers the better access for input and output markets, which motivates them for better utilization and management of their resources. Those farmers who are producing higher number of AIVs and also AIVs as their main crop are found to be technically efficient than their counterparts. This might be plausible given the fact that farmers devote themselves more towards their main crop compared to other crops. Higher livestock ownership increases technical efficiency for AIV producers.

Table 1: Factors influencing technical inefficiency

Variables	Technical inefficiency score		
	Coeff.	Std. Err.	P>z
Peri-urban	-1.995	0.418	0.000
Market share	0.080	0.292	0.784
Gender	-0.396	0.276	0.152
Age	0.016	0.010	0.115
Total land	-0.114	0.165	0.489
Group	0.380	0.255	0.136
Education	-0.306	0.331	0.355
Experience	-0.005	0.010	0.600
Savings	-0.699	0.252	0.006
Risk	-0.099	0.045	0.030
Information	-0.207	0.244	0.396
Distance	-0.082	0.062	0.189
TLU	-0.173	0.083	0.036
Shock	0.363	0.314	0.248
Owned land	0.099	0.371	0.789
AIV as main crop	-0.546	0.252	0.031
Number of AIV	-1.313	0.237	0.000
Constant	6.068	0.726	0.000

Source: Own calculations

Impact of technical efficiency on income and food security

Table 2 reports the estimates of average treatment effects of technical efficiency on household income, FCS and HDDS. We find that higher technical efficiency significantly increases income and FCS as compared to lower technical efficiency. Households having technical efficiency lower than or equal to 0.11 have significantly lower households' income in a range of 2098.28 to 2149.52 PPP$. Similarly, the FCS and HDDS are significantly reduced by 10.92 to 11.59 and 0.33 to 0.38, respectively. On the other hand, households having technical efficiency higher than or equal to 0.43 had significantly higher households' income in a range of 2247.94 to 2661.81 PPP$. Similarly, higher technical efficiency significantly increases FCS in a range of 4.17 to 5.34. However, no significant difference is seen in HDDS in case of higher technical efficient producers.

Table 2: Average treatment effect using nearest neighbor matching and radius matching algorithm

Category	NNM		Radius	
	ATT	S.E	ATT	S.E
HHs with TE<=0.11 vs HHs with TE>0.11				
Income (PPP$)	-2149.52***	469.75	-2098.28***	496.90
FCS	-10.92***	2.07	-11.59***	2.60
HDDS	-0.33**	0.14	-0.38**	0.16
HHs with TE>=0.43 vs HHs with TE<0.43				

Income (PPP$)	2661.81***	718.01	2247.94***	677.17
FCS	4.17**	1.84	5.34***	1.99
HDDS	0.04	0.16	0.08	0.15

Note: ATT: average treatment effect on the treated; S.E: bootstrapped standard error
Statistical significance at 5% and 1% level
Source: Own calculations

Conclusion

To improve households' income and food security situation, resources need to be utilized properly either through conserving it or through increasing the efficiency. In this article, we have estimated the technical efficiency of AIV producers of rural and peri-urban Kenya, determined the factors influencing technical inefficiency and analyzed the impact of technical efficiency on different indicators measured by household income and food security. The present research applied one stage stochastic production frontier estimation and PSM. Our econometric results reveal some interesting findings. Evidence of a wide variation of technical efficiency among AIV producers exists. Location to peri-urban areas, savings, commercialization, growing AIV as main crop and diversification of AIVs are found to significantly increase technical efficiency. In addition, we could show that higher technical efficiency leads to higher income and higher FCS of households. The implication of this study is that technical efficiency of AIV producers could be increased by 72% through better use of available resources given the existing technology. The results of this study stress the need for appropriate policy formulation and implementation to enable farmers reduce their inefficiency.

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