The Relationship between Technical Efficiency In Food Crop Production And Household Wealth In Uganda: Evidence From Maize Farming Households between 2005-2010

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Abstract:

This paper provides insight into the relationship between technical efficiency of maize farming and household wealth indicators in Uganda. The study uses national panel data in 2005/06 and 2009/10, and a stochastic frontier production function model is specified for the maize farming households. Up to 2,295 households were found to have grown maize in 2005/06, and 2,343 households in 2009/10 from the data sets. The results show that up to 86% of the maize farming households attained on average low mean efficiency scores below 0.5. While inorganic fertilizer was found to be important in contributing to maize productivity and therefore technical efficiency, the number of households using it between the two time periods was found to reduce albeit not significantly. The number using organic fertilizer though, significantly increased (1%). Household wealth is found to be significantly (1% level) associated with a reduction in technical efficiency. The study recommends interventions targeted at poor rural households to improve maize output markets so as to competitively reward household investment in production, and subsequently generate household wealth. This would make maize production attractive to the producers, motivating them to make necessary investment in inorganic fertilizer and other purchased inputs.

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Key Words: Technical Efficiency, Household Wealth, Stochastic Frontier Production Function

1. Introduction

It is widely accepted that improvements in agricultural production efficiency have potential to increase the wealth of small holder farmers and hence reduce poverty. Theoretically, changes in agricultural production may affect poverty through higher incomes for the farmers, more employment on-farm as cultivated area expands and/or frequency of cultivation increases, and reduced food prices for both urban and rural poor, among other things (Irz *et al.*, 2001). By directly observing changes in agricultural productivity and poverty, and then estimating the degree to which they are related, empirical evidence equally alludes to the poverty alleviating effects of agricultural growth (Irz *et al.*, 2001). These effects may be observable through a number of ways including; increases in land productivity (Datt and Ravallion, 1996 in Irz *et al*., 2001); technology adoption (Mendola, 2007; Langyintuo and Mungoma, 2008; Kassie *et al*., 2011); and credit access impacting on the efficiency of production (Komicha and Ohlmer, 2007). However the degree to which these factors are able to translate agriculture, particularly food crop production, into wealth for the smallholder farmers depends on a diversity of circumstances.

In Uganda, Maize (*Zea mais*) is an important staple food crop. It is particularly important for the urban poor, used by institutions, hospitals and the military (Okoboi, 2010) and a major source of income for most farmers in the eastern, northern, and north-western Uganda (Ferris *et al.*, 2006). Other than food, maize has a wide range of other uses including processing of livestock and poultry feeds, making of local brew, and a number of industrial formulations, making it the most traded food crop. Statistics from the Uganda Census of Agriculture indicate that in 2008/09, maize was cultivated on an estimated area of 806, 627 Ha (UBoS, 2010). The eastern region produced the highest contribution of 46.9%, followed by western (21.1%), central (19%) and the northern region producing the least (12.9%) (UBoS, 2010). Maize is one of the crops that dominate food crop production in terms of the land area allocation (UBoS, 2010; Mugisha *et al.*, 2011) Maize yield was equally highest in the eastern region at 2.9mt/Ha, followed the western (2.6 mt/Ha), central (2.3 mt/Ha) and least in the northern region (1.2 mt/Ha). Maize exports have often constituted the highest proportion of agricultural exports of the country; for example at 103,950 MT in 2013 (IFPRI, 2017). Due to its importance both for household food and income, the government of Uganda has selected maize as a strategic food security crop and one of the 10 priority crops to be supported in the second National Development Plan (RoU, 2015).

Generally, Uganda has a well-developed set of plans, implementation strategies and instruments that have contributed significantly to economic growth and poverty reduction (Okidi, 2002). Using national household survey data, analysts have established that the incidence of income poverty declined from 56% in 1992 to 35% by 2000 (Okidi, 2002). There is no doubt that the sustained growth led to significant reduction in poverty. However, the high population growth and poor performance of agriculture have greatly slowed down poverty reduction in absolute terms. The poverty headcount has consistently declined from 31% in 2005/06 to 24.5% in 2009/10, and further down to 19.7% in 2012/13 (UBoS, 2016). Whereas economic growth has improved over the years and absolute poverty reduced to 19.7%, this growth has not generated the momentum needed to transform Uganda's economy at the pace anticipated in Uganda Vision 2040 (UBoS, 2016).

Research findings from poverty studies in Uganda show that income poverty is associated with a number of factors, including household characteristics such as household size, sex of household head and level of education (Sewanyana, 2009), land, livestock and asset ownership (Ellis and Freeman, 2003; Ellis and Bahiigwa, 2003; and a diversity of on-farm and non-farm income sources (Ellis and Freeman, 2003). At community level, infrastructure; feeder and tarmac roads, are believed to make it easier to establish other facilities such as electricity, markets and schools which impact the lives of individuals and communities (Sangay and Barios, 2009). Further, the incidence of income poverty has a spatial dimension. Rural households, and those that are geographically isolated are likely to be associated with poverty (Sangay and Barios, 2009; Sewanyana, 2010). While a number of interventions have been introduced in maize production to improve productivity, with the aim of poverty reduction among the farming households, the many poverty studies do not relate food crop productivity with the factors associated with poverty. The relationship between these factors and household production efficiency would enable the formulation of policies targeted at specific aspects that are likely to result into the desired crop output and subsequent wealth creation.

The purpose of this paper is to provide insight on the relationship between technical efficiency and household wealth for maize farming households between 2005-2010. Specifically technical efficiency of the maize farming households is estimated, and its relationship with the selected household wealth indicators determined.

2.0 Data and Methods

2.1 Data

The study uses panel data that combines two national household surveys conducted by the Uganda Bureau of Statistics (UBoS); in 2005/06 and 2009/10 periods. Data were collected for the period July-December, 2004 also called the second season in the 2005/06 data set, and January-June 2005 called the first season. Data for the 2009/10 data set was collected for the second season, July-Dec, 2008, and the first season January-June 2009. The study was national in context, since households were drawn from all the districts of Uganda. The production inputs that were considered were; the land acreage under the crop or crop area, family labour used in person days, the value of hired labor, the value of purchased inputs of organic, inorganic fertilizers, and chemicals (pesticides and herbicides). The yield of maize was obtained in kilograms per acre of land planted. The factors expected to influence technical efficiency include household characteristics such as age, sex, education level of the household head, value of livestock owned, household assets, off farm income among others.

UBoS has conducted a number of well executed nationally representative cross-sectional household surveys since 1989 (UBoS, 2009). The Uganda National Panel Survey (UNPS) which entails a multi-topic panel household survey was implemented in 2009 with an initial sample as a sub-set of 3,220 households, selected from 7,426 households visited in the 2005/06 survey. This initial sample was intended to be revisited in 2009/10, but the actual number of households that were visited were 2,556. It is from this sample that the study households that participated in in maize growing were selected. While a number of households in the UNPS data set were found to have grown maize, it would not be possible to capture the same numbers in the two time periods of the study, resulting into attrition. The reasons for this were that some of the households that grew maize in 2005/06 and were followed in 2009/10, did not grow the same crop, or had missing values in recording the data. It is also possible that new households participated in growing maize when they had not grown in 2005/06, and hence more households were considered in 2009/10. Therefore the number of households considered in the study were 2,295 and 2,343 in 2005/06 and 2009/10 respectively.

2.2 Model specification

The stochastic frontier production function methodology is used to describe the production of the Ugandan farming households using the linearised Cobb-Douglas production frontier model. Several household characteristics affect efficiency differentials among farmers although the effect of these characteristics varies in time and space depending on specific situations in different countries (Coelli and Battese, 1996 in Komicha and Ohlmer, 2007). Following the specification by Battese and Coelli (1995) for panel data which assumes the presence of technical inefficiency in production, the stochastic frontier production function model that is specified for the Ugandan farming households is defined below;

$$\ln(Y_{it}) = \beta_0 + \beta_1 \ln(value\_org)_{it} + \beta_2 \ln(value\_Inorg)_{it} + \beta_3 \ln(value\_pest)_{it} + \beta_4 \ln(value\_HRDLB)_{it} + \beta_5 \ln(famlbdays)_{it} + \beta_6 (Year)_{it} + v_{it} - u_{it}$$

……………………………………(1)

Where ln represents the natural logarithm (i.e to the base *e*),

Y_{it} represents the quantity (kg per acre) of maize crop harvested by the *i-th* household at the *t-th* observation,

$value\_org$ is the sum of money spent on purchasing organic fertiliser per acre,

$value\_inorg$ is the amount (Ug.shs) per acre, spent on purchasing inorganic fertiliser, $value\_pest$ is the amount (Ug.shs) per acre, spent on purchasing chemicals such as pesticides, and herbicides.

$value\_HRDLB$ is the amount (Ug.shs) per acre, spent on hired labour in a given year,

famlbdays represents the total number of person days of family labour per acre, in a given year,

Year represents the time period of the observation (expressed in terms of 1, 2)

$\beta_0 ...... \beta_6$ are unknown parameters to be estimated,

v_{it} And u_{it} are as explained in (1) above, so that;

$$u_{it} = \delta_0 + \delta_1 age_{it} + \delta_2 sex_{it} + \delta_3 Hhsize_{it} + \delta_4 educ_{it} + \delta_5 value\_assets_{it} + \delta_6 value\_lvstk_{it} + \delta_7 No.ext\_visits_{it} + \delta_8 off\_farm_{it} + \delta_9 HI_{it} + \delta_{10} location_{it} + \delta_{11} crop\_area_{it} + \delta_{12} time_{it}$$

…………………………………………………………………(2)

Where *age* represents the age of the household head measured in years,

sex represents the sex of the household head, (dummy so that male=1, otherwise=0)

Hhsize represents the number of members in a household,

Educ represents the number of years of schooling of the household head,

Value_assets represents the value of assets (shs) owned by the household,

Value_lvstk represents the value of livestock (shs) owned by the household,

No.ext_visits represents the number of extension visits received by the household in one year,

Off_farm represents off farm income received by the household in one year,

HI represents Housing Index assigned to a given household,

Location Location of the household (Urban=1; rural=0)

crop_area represents the total area in acres under the food crops harvested,

time represents the time period of observation (i.e 1, 2,)

$\delta_0 .... \delta_7$ are unknown parameters to be estimated.

The method of maximum likelihood is used for the estimation of the parameters of the stochastic frontier using STATA version 13. The prediction of technical efficiencies is based on its conditional expectation, given the model assumptions. The technical efficiency of production for the *i-th* household at the *t-th* observation is defined as follows;

$$TE_{it} = \exp(-u_{it}) = \exp(-z_{it}\delta - W_{it})$$ ……………………………………….(3)

Where u_{it}, z_{it}, δ and W_{it} are as explained above. The technical efficiency of a household lies between zero and one and is inversely related to the inefficiency effect.

The model for the technical inefficiency effects is run by regressing the technical efficiency scores on selected household socio-economic characteristics and other factors believed to be associated with them. The likelihood function is expressed in terms of the variance parameters, σ_s^2, and γ such that;

$$\sigma_s^2 = \sigma_v^2 + \sigma^2 \quad \ldots\ldots (4)$$

and $$\gamma = \frac{\sigma^2}{\sigma_s^2} \quad \ldots\ldots (5)$$

The γ parameter has a value between zero and one.

2.3 Determination of Housing Index (HI)

The Housing Index (HI) was used as a proxy for a measure of the wealth of households. The Variables were selected that had information related to the household socio-economic status, including housing characteristics, water source, and access to sanitation facilities. The housing characteristics included roof, floor and wall materials. The index was created for each household using the *factor-rotate-predict* command in STATA.

3.0 Results and Discussion

3.1 Descriptive statistics of selected maize farming household characteristics

Selected household characteristics, value of purchased and other inputs, and the yield of maize in the two panel survey waves are described in Table 1 below. The average age of the household heads significantly increased from 44 years to 47, understandably due to the difference between the two time periods of the panel survey which was 4 years. During the same period, household sizes significantly increased, at the 1% level, from 6 to nearly 7 members. In an eight year (1992-2000) panel data study from nationally representative household surveys conducted by the Uganda Bureau of Statistics, Sewanyana, 2009 observes that households that were persistently poor had relatively more persons per household than those that were not, and that smaller family sizes had consistently moved out of poverty over time. This was also earlier observed by Sewanyana and Bategeka, 2007. According to Sewanyana, 2009, there was a likelihood that large households, with over 6 members would be associated with poverty. On average the sample households in this study are therefore likely to be associated with poverty due to large family sizes.

The number of female headed households significantly increased at the 10% level from 26% to 29%. Abuka *et al.*, 2007 note that although female headed households in Uganda were not necessarily poorer than their male headed counterparts in 2003, there were some dimensions of poverty in which women were generally at a disadvantage (Lawson, 2004 in Abuka *et al.*, 2007). For instance, households headed by women widows were found to be consistently poorer than others; female headed households had less land than male headed households; women also tended to participate less in the labour market than men and women's wages were found to be significantly lower than men's (Abuka *et al*., 2007). In this study therefore, given the disadvantages that women face in these poverty dimensions, a significant increase in the number of female headed households would necessitate focused attention towards such households to enable them achieve optimal levels of maize production and efficiency.

The majority of maize farming households (up to 63%) were located in the rural areas. Residence in rural areas in Uganda is associated with a higher incidence of poverty where the proximate explanations of rural poverty relate to access to productive resources and opportunities for gainful employment (Abuka *et al.,* 2007). In fact, rural areas are said to have a disproportionate contribution of over 90% to national poverty (Sewanyana, 2010). Abuka *et al.*, 2007 propose that the solution to reducing vulnerability to poverty in rural areas lies in improving agricultural productivity among other things. On average, household heads in this study were found to have spent 6 years at school, which represents minimal formal education, at primary level. Education is one of the key factors influencing a change in a household's poverty state in Uganda; of either slipping into or moving out of poverty. At least the ability of a household head to read and write has been found to reduce the chances of a household being poor (Sewanyana and Bategeka, 2007). In addition to the location of the majority of the sample households in rural areas, the low level of education seems to disadvantage them in terms of the ability to look for alternative sources of livelihood.

The use of purchased inputs in the production of maize was found to be minimal as represented by the low amounts recorded to have been spent (Table 2). The results, none the less show further, a significant reduction in the amount of money spent on them, and consequently a further reduction in their use; in particular inorganic fertilizer, herbicide/pesticide, and hired labour. There was also a significant reduction in the number of households using herbicide/pesticide, hired and family labour, between the two time periods (Table 2). Kasirye, 2013 observes the limited use of inorganic fertilizer in Uganda's agriculture as due to supply-side constraints. Agricultural technologies in general and inorganic fertilizer in particular, are not readily available in agricultural markets, and sourcing such inputs from distant markets may reduce profitability and delay their adoption (Kasirye, 2013). It is therefore not surprising that during the study period, the households using purchased inputs not only reduced significantly, but the amount spent on them also reduced. Kasirye, 2013 further observes that households that kept cattle within the same time period (2005-2010) were more likely not to adopt, as well as dis-adopt, inorganic fertilizer due to the availability of organic fertilizer/animal manure with the presence of livestock on their farms. This study finds that it is only the number of households using organic fertilizer that significantly increased at the 1% level between the two time periods, although the value purchased did not increase significantly. Indeed farmers rarely purchase organic fertliser/manure as they obtain it from their farms. It is a cheaper although less effective alternative, and less amenable to supply-side constraints than inorganic fertilizer (Kasirye, 2013).

Table 1 Descriptive statistics of selected maize farming household characteristics between 2005-2010

	2005/06			2009/10			
Variable	**Obs.**	**Mean**	**Std.Dev**	**Obs.**	**Mean**	**Std.Dev**	**Mean Difference**
Household characteristics							
Age (years)	2, 291	43.67	15.48	2,192	47.49	15.04	3.83***
Sex of household head (male=1; female=0)	2,291	0.74	0.44	2,194	0.71	0.45	-0.027*
Household size	2,293	6.26	3.2	2,194	6.76	3.3	0.5082***
Education (years of schooling)	2,280	5.82	5.11	2,194	5.76	5.34	-0.053
Location (urban=1; rural=0)	2,295	0.37	0.48	2,343	0.38	0.48	0.0038
Value of purchased inputs (shs)							
Organic fertilizer	2,295	58.91	1,581.19	2,343	117.07	2,961.52	58.158
Inorganic fertilizer	2,295	316.97	7,122.79	2,343	54.58	1,749.64	-262.382*
Herbicide/Pesticide	2,295	423.37	5,198.49	2,343	203.83	2,613.24	-219.534*
Hired labour	2,295	7,508.49	40,071.29	2,343	4,068.66	32,738.49	-3439.83***
Other inputs							
Family labour (person days)	2,295	22.98	46.65	2,343	248.36	3,645.65	225.37***
Maize area (acres)	2,295	0.49	0.89	2,343	0.62	2.66	0.118*
Yield (kg/acre)	2,295	908.93	2,023.14	2,343	1,511.14	2,128	602.2***

(Source: Author's computations from the UNPS data sets 2005/06 and 2009/10 collected by UBOS)

The significant reduction in the value of hired labour and number of households using it, coincides with a significant increase (at 1% level) in family labour days for those households that continued to engage between the two time periods. The mean area under maize significantly increased at 10% level, from 0.49 – 0.62 acres per household. This falls within the range that was estimated by UBoS, 2010 to be 0.45 acres in 2005 and 0.86 acres in 2010 by UBOS (2010). Although there was a reduction in the value of purchased inputs, as crop area significantly increased, the yield too significantly increased from 908.93 – 1,511.14kg/acre. The results show that the input that was increasingly engaged to contribute to increased yield was family labour effort, as indicated by the significant increase in person days between the two waves.

The use of family labour effort was intensified between the two time periods. Not only was it intensified, it also positively and significantly contributed to maize yield during the study period, at the 1% level. In addition, hired labour and inorganic fertiliser, in spite of significant reduction in the values engaged, are found to significantly increase maize yield both at the 1% level (Table 3).

Table 2 Proportion of sample households using the selected inputs between 2005/06 and 2009/10

Input	% of Households using inputs				
	2005/06		2009/10		
	Obs.	% Hhs using	Obs.	%Hhs using	%Change
Organic fertilizer	2,295	0.57	2,343	1.32	10.76***
Inorganic fertilizer	2,295	1.48	2,343	1.32	-0.16
Pesticide/Herbicide	2,295	3.05	2,343	1.54	-1.51***
Hired Labour	2,295	24.88	2,343	7.55	-17.33***
Family Labour	2,295	65.62	2,343	19.04	-46.59***

(Source: Author computations from UNPS data collected by UBOS, 2005/06 and 2009/10)

3.2 Results of the stochastic production function

Using model (1) above, the natural log (ln) of maize yield (kg/acre) is regressed on the natural logarithm of the value per acre, of purchased inputs, namely; organic fertilizer, inorganic fertilizer, herbicide/pesticide, hired and family labour. The results of the regression are shown in Table 3. The constant (β_0) is significant at the 1% level, indicating that the selected variables are significantly important in describing maize yield among the farming households. The value of inorganic fertilizer, hired and family labour are especially found to significantly contribute to maize yield, all at the 1% level. While these inputs are found to be beneficial to enhancing maize yield, the value of inorganic fertilizer and hired labour is found to have significantly reduced in the study period. Only family labour effort would be intensified. The *Year* variable, in the Battese and Coelli, 1995 specification represents technical change. The results show significant technical progress (1% level) between the two time periods. In this study, it is possible that increased family labour effort was also associated with improved technical management such as using recommended agronomic practices that would increase the person days of family labour. Hence significant technical progress and family labour use.

The reasons for the limited use of the purchased inputs in this period are well documented by Okoboi, 2010; Okoboi and Barungi, 2012; Kasirye, 2013 to include unavailability of the inputs, lack of knowledge on use of and market information on fertilizer, low access to credit and constrained access to input and output markets, among others. In view of these constraints, Okoboi, 2010, finds that farmers who grow maize on plot sizes that are less than 1 ha, and use purchased inputs, stand to make economic losses, due to high marginal cost compared to the marginal revenue that would arise from increased output associated with their use. This situation therefore has implications, not only on current yield potential, but technical efficiency of the farming households at the existing level of technology.

Table 3 Results of the stochastic production function

Variables	Parameter	Coeff.	Std.err
Stochastic production frontier			
Constant	β_0	1.669***	0.331
ln (value of organic fertiliser)	β_1	0.057	0.051
ln (value of inorganic fertiliser)	β_2	0.099***	0.036
ln (value of pesticide/herbicide)	β_3	0.044	0.027
ln (value of hired labour)	β_4	0.115***	0.009
ln (family labor days)	β_5	0.949***	0.019
Time	β_6	3.137***	0.206
Variance parameters			
Sigma sq.		2.031***	
Gamma		0.227***	
Log likelihood		-10546.57	
No. of observations		4638	

The returns to scale arising from the output elasticities of the inputs are shown in Table 4 below.

Table 4 Returns to Scale (RTS) of the maize farming households

Inputs	Coeff.
Organic fertiliser	0.057
Inorganic fertiliser	0.099***
Pesticide/Herbicide	0.044
Hired Labour	0.115***
Family Labour	0.949***

Returns to Scale (RTS)	**1.264**

(*** significant at the 1% level: Table extracted from Table)

The resultant returns to scale indicate that a 1% increase of the inputs at the given values would result in approximately 1.3% increase in maize yield. It would therefore be advisable, at the existing technology and input values, to expand the use of the inputs for further yield improvement.

3.3 Technical Efficiency of the maize farming households

The technical efficiency scores of the maize farming households were obtained from the specified stochastic frontier production function (1) above. The range of the scores across the households, over the study period, are shown in Table 5 below. The results show that during the period, up to 86% of the maize farming households attained efficiency scores below 0.5. This means on average they only achieved 50% of the maximum possible maize production, at the current level of technology, during the study period; an indication of a large aggregate loss of output. Moreover, technical efficiency scores did not even change significantly between the two time periods, as shown by the *ttest* results in Table 6. There is still plenty of room (50%) for improvement in productivity and technical efficiency and hence need for technology improvements.

Table 5 The range of technical efficiency scores of the Maize farming households between 2005-2010

Range	Cumulative %
0.00 ≤ 0.1	0
0.11 ≤ 0.2	4.1
0.21 ≤ 0.3	46.44
0.31 ≤ 0.4	70.85
0.41 ≤ 0.5	85.64
0.51 ≤ 0.6	93.4
0.61 ≤ 0.7	96.72
0.71 ≤ 0.8	98.15
0.81≤ 0.9	99.14
0.91 ≤ 1.0	100
Mean	0.354
Standard Deviation	0.145
Minimum	0.131
Maximum	1
No. of Observations	4,638

(Source: Author computations from UNPS data collected by UBOS, 2005/06 and 2009/10)

Table 6: Change in mean technical efficiency scores between 2005-2010

Food Crop	2005/06 Obs.	2005/06 Mean	2005/06 St.dev.	2009/10 Obs.	2009/10 Mean	2009/10 St.dev.	Mean difference (*ttest*)
Maize	2,295	0.353	0.146	2,343	0.355	0.143	0.0019

(Source: Author computations from UNPS data collected by UBOS, 2005/06 and 2009/10)

3.4 Factors contributing to technical efficiency

The inefficiency effects model (2) was used to determine the factors that contribute to technical efficiency of the maize farming households. The results of this model are shown in Table 7.

Table 7 Results of the Inefficiency effects model

Variables	Parameter	Coefficient	Std. Err.
Inefficiency effects model			
Constant	δ_0	0.3608***	0.0126
Age (yrs)	δ_1	0.00016	0.00015
Sex of household head (1=male; 0=female)	δ_2	0.0014	0.00517
Education level (None)	δ_{30}	-0.03003***	0.00873
Education level (Primary)	δ_{31}	-0.0243	0.0075
Education level (Secondary)	δ_{32}	-0.01315	0.0009125
Household size	δ_4	0.000209	0.0007
Value of livestock (shs)	δ_5	0.0000483	0.00005
Value of household assets (shs)	δ_6	0.000537**	0.00027
Number of extension visits (shs)	δ_7	-0.00057	0.00078
Off-farm income (shs)	δ_8	-0.000029	0.000039
Location (1=urban; 0=rural)	δ_9	-0.0155***	0.0046
Crop Area (acres)	δ_{10}	0.000852	0.00014
Housing Index (5 Quantiles)	δ_{11}	0.00733***	0.00254
Year	δ_{12}	-0.00194	0.0045
R-squared		0.0133	
No.of observations (n)		2, 340	

(Source: UNPS data collected by UBOS, 2005/06 and 2009/10)***,**,* significant at the 1%, 5% and 10% levels

3.4.1 Household characteristics and technical efficiency

The factors contributing to the observed technical efficiency were further investigated. The most important factor that was found to be associated with efficiency in maize production was the education of the household head. While in all categories of household heads; those with no education, primary, and tertiary levels, education is found to reduce technical inefficiencies. This is especially so with the category that had no education at all. The coefficient of the parameter, δ_{30}, representing no education at all, was significant at the 1% level (Table 4), implying that among the uneducated, chances of improving technical efficiency if they are educated are very high. Several studies agree with the finding that the level of education positively influences technical efficiency. Chepng'etich *et al*., 2015 in an investigation of the factors that influence efficiency of sorghum production in Kenya find that the education of a farmer positively influences technical efficiency. Irz *et al*., 2001 find that the level of education of a household head significantly affects technical efficiency of farmers. Education is expected to increase labour productivity by influencing managerial skills of farm operators, as skilled farmers are more likely to allocate resources efficiently (Irz et al., 2001). Education was also found to significantly reduce inefficiencies among Ethiopian farmers (Komicha and Ohlmer, 2007). Urban households were significantly associated with reduced inefficiency (1%) when compared to their rural counterparts. Urban areas normally have the advantage of proximity to good input and output markets in the urban, and ease of transportation. When the farmers access good market, with good prices, they are more likely to continue making investments of purchased inputs, raising technical efficiency.

The number of extension visits to a household and off-farm income, both have the expected negative sign. Although not significant, they are found to reduce inefficiency in maize production. A number of studies allude to the positive effect of extension services in improving crop production and technical efficiency and that of off-farm income especially towards the purchase of farm inputs and capital investments (Pfeiffer et al., 2009; Oseni and Winters, 2009; Klick et al., 2009; Davies et al., 2009). Household size on the contrary is found to have a positive sign, indicating that large household size increased inefficiencies in maize production during the study period. A similar result was obtained by Komicha and Ohlmer, 2007 who found large household sizes to significantly reduce technical inefficiencies among small-holder farmers in Ethiopia, especially those that were not credit constrained. This was linked to the ability of such households to choose optimal levels of labour because they were not financially constrained. However the finding was not significant in this study.

3.4.2 Household wealth and technical efficiency

The factors that are commonly associated with the wealth of households include land and livestock ownership, household assets, nature of house and roofing material, among others. According to studies by Ellis and Bahigwa, 2003; Ellis and Freeman, 2006, better off households are distinguished by virtuous spirals of accumulation of land and livestock ownership, while the lack of these two assets is strongly associated with rural poverty in many sub Saharan Africa countries (Ellis and Mdoe, 2003). Langyintuo and Mungoma (2008) observe that in rural areas, households on the lower wealth continuum behave differently from those on the higher level when it comes to adoption of new agricultural technologies. As such, the household wealth indicators selected for this study were; value of livestock owned by the household, value of household assets, maize crop area, and housing index.

Households with a higher value of household assets are found to be associated with increased inefficiency, significant at 5% level. Housing index was significantly associated with increased inefficiency at the 1% level. This means that households that had better housing index; good housing characteristics, access to safe water and sanitation facilities, had greater inefficiency in production. The value of livestock owned and large maize crop area were both associated with increased inefficiency, although not significant. Based on these wealth indicators, this study finds that households that are relatively wealthy are less technically efficient than others. Studies in Uganda show that access to productive assets including livestock may provide rural households with tremendous opportunity to generate income and to move out of poverty (Ellis & Bahiigwa 2003; Ellis & Freeman 2004). At the same time, rural poverty is strongly associated with lack of land and livestock, as well as inability to secure nonfarm alternatives to diminishing farm opportunities, and reliance on food crop production (Ellis & Bahiigwa 2003; Ellis & Freeman 2004). However, it is likely that the income obtained from such assets to create the wealth, to a great extent is not invested in improving maize productivity. In a similar study in Gambia, livestock earnings were found not to contribute to farm productivity (Chavas *et al*. 2005).

4 Conclusion

This study estimates technical efficiency of the maize farming households in Uganda between 2005-10 and its relationship with selected household wealth indicators is determined. The mean household technical efficiency score is found to be low at 0.35, and did not significantly change during the study period. The inputs that were found to significantly contribute to this efficiency were inorganic fertilizer, and both hired and family labour. Yet during the study period, there was a decrease in the number of households using inorganic fertilizer and a significant increase in number of households using organic fertilizer. Returns to Scale from the use of these inputs indicate that expansion of their use would result in improvements in yield and hence technical efficiency. Household characteristics associated with technical efficiency include education level of the household head, and location of the household in the urban area. However, household wealth is found to be associated with technical inefficiency in maize production. This study recommends interventions targeted at poor rural households to improve access and use of purchased inputs and access to good output markets that would make maize production more attractive to the producers, motivating them to make the necessary investment in purchased inputs.

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