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Estimating the Efficiency of Maize Farmers in Ghana

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Authors' contributions

This work was carried out in collaboration between all the authors. Authors GS designed the study, wrote the protocol, performed the statistical analysisand wrote the first draft of the manuscript. Authors SAB and DPKA managed the literature searches, proofreading and corrections on the manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

A lot of investment has been made in the agricultural sector of Ghana to increase agricultural production through the introduction of new technologies. However, it has been observed that despite efforts being made by the government through the introduction of new varieties of maize the productivity of maize farmers is generally low.
Aim: This study sought to assess the efficiency of farmers.
Place: In Nkoranza, BrongAhafo Region, Ghana at 1º 10'W and 1º 55'W and latitudes 7º 20N and 7º 55N.
Methodology: The study employed the stochastic frontier model by fitting a Translog production function for the 2008 cropping season. The socio-economic and management practices that influence technical efficiency were determined. Input elasticities as well as allocative efficiency of the farmers were also determined.
Results: A mean technical efficiency of 91 percent was obtained for maize farmers. There was a distinct variability in mean technical efficiency among farmers cultivating the improved variety and those cultivating the local variety. Variety of maize cultivated by the

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farmer, sex of the farmer, experience of maize farmer, distance of the farm from the farmers' residence and number of times a farmer gets extension visits were found to have significant effect on technical efficiency. Allocatively, maize farmers were found to be over utilizing labour but underutilizing fertilizer and seeds in the study area. The study recommended that more extension staff should be trained so that their services could be extended to more farmers.

Keywords: Maize; technical efficiency; allocative efficiency; stochastic frontier; Nkoranza north and south districts; brongahafo region; Ghana.

1. INTRODUCTION

A lot of empirical work on technical efficiency of farmers in the developing world has been carried out following Schultz [1] 'poor but efficient' hypothesis. This hypothesis greatly influenced most development thinkers at the time by showing that there were actually few or no possibilities for increasing agricultural production with available resources other than expanding the production possibility frontiers through new technology. In Ghana, however, not much attention has been paid to allocative and technical efficiency of farmers in the Ghanaian agricultural sector [2].

Many developing countries, Ghana inclusive, have made a lot of investments in agricultural sector. Despite these considerable investments in the sector, agricultural production in developing countries encounters substantial inefficiencies due to farmers' high degree of unfamiliarity with new technology, poor extension and education services, and poor infrastructure, among others [3].Further, there is limited ability and/or willingness to achieve full adjustment of input levels on the part of producers due to their long adaptability to traditional practices and institutional and cultural constraints [4,5].

Since independence, 56 years ago, agriculture has continued to play a central role in the livelihoods of Ghanaians. It employs about 56% of the population and accounts for 28.3% of Gross Domestic Product (GDP). The specific situation of Nkoranza is no different, as the only major economic activity in the area is farming. The region is the largest producer of maize in Ghana contributing 29% to the national production and Nkoranza area is the largest contributor in the region. Maize is the most important cereal crop on the domestic market in Ghana. Maize accounts for 55 percent of grain output followed by paddy rice (23 percent), sorghum (13 percent) and millet (9 percent). Maize is also an important component of poultry feed and to a lesser extent the livestock feed sector as well as a substitute for the brewing industry.

The crop is grown in all the ecological zones of the country. However, the cultivation and production differs in these ecological zones. Between 1986 and 1989 about 620,000 hectares of land area allocated to cereals was planted with maize [6]. Maize is also a politically sensitive crop; a popular food "kenkey" prepared from it was once brought to the Parliament of Ghana where the size and price of a ball was used as a measure of the state of the economy. Maize has recently surpassed cassava as Africa's most important food crop in terms of calories consumed [7] and also doubles as a main source of income for the producers in the maize surplus regions. Maize is also associated with household food security such that a low-income household is considered food insecure if it has no maize stock in store, regardless of other foods the household has at its disposal [8].

Ghana has a potential for the production of maize especially along the transitional zone of the country. In time past, Ghana was noted for the exportation of maize to neighbouring countries such as Mali and Burkina Faso. However, it has been observed that despite the efforts made by the government and the Ministry of Food and Agriculture particularly through the introduction of new varieties of maize and fertilizer subsidy, the productivity of maize on farmers' fields is generally low, averaging 1.55mt/ha [9,10] as against an estimated achievable yield of around 6 Mt/ha [11].However, it was not possible to explain to what extent the existing low levels of productivity in maize could be attributed to.

The presence of these shortfalls means that output could be increased without requiring additional conventional inputs and without the need for new technologies. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving productivity and efficiency (technical and allocative efficiency) of maize with a given technology. From the foregoing, this study, therefore seeks to estimate the efficiency of maize farmers in the Nkoranza area.

1.1 Organization of the Study

The study is composed of four parts: the first part contains the background and objectives of the study. The second part gives an outline of the methodology used to address the objectives of the study and a description of the study area. The results are presented and discussed in the third part and conclusions and recommended drawn from the study follows.

2. METHODOLOGY

2.1 Sampling Procedure, Sample Size and Data Collection

The study employed purposive sampling procedure in selecting the study area due to their dominance in maize production. The Ministry of Food and Agriculture has grouped the area into 32 operational areas. The 32 operational areas were put into two clusters representing Nkoranza north and Nkoranza south. Three operational areas were then selected from each cluster and simple random used to select 22 communities. The final respondents of ten were thereby selected using simple random technique from each community. This gives a total of 200 respondents.

A cross sectional, farm level data was collected for the 2008 cropping season using a questionnaire. The use of this questionnaire was guided by face to face interviews. The data covered the production, social, economic and the socio-demographic characteristics of the farmers.

2.2 Summary Statistics of Production Variables

Agricultural production like any other enterprise depends on the use of inputs. These inputs are transformed into output through the production process. Thus, without the use of these inputs, there would be a zero output. The average maize output obtained in the study area was 3,182 kg/ha. And this output level is obtained on a 0.90 ha of farm land and using 374.75 kg of fertilizer, 1.35 litres of agro chemicals, 47.84 kg of seeds and man days of 714.34.

2.2.1 Conceptual framework

The notion behind the stochastic frontier is to separate the lump effect of exogenous shocks both fortunate and unfortunate, together with the effects of measurement error and inefficiency into a single one sided error term (as usual in previous estimations). Thus the stochastic frontier model by [12] and [13] is able to separate the error term into two component; (1) a two-sided, symmetric component that permits random variation of the frontier across farms and which also measures the usual effects of measurement error and random shocks out of the reach (control) of the farm e.g. weather, strikes etc., and (2) a one-sided component responsible for farms inefficiency relative to the stochastic frontier [14]. This yielded the stochastic frontier to be specified as [12].

$$In(y_i) = f(x_i, \beta) + v_i - u_i, \;\; i = 1,2 \ldots \ldots \ldots N$$

where y_i measures the quantity of output of the ith firm, $x_i$is a vector of the input quantities, β a vector of parameters, $f(x_i, \beta)$ is a suitable production function, $v_i$was assumed to be independently and identically distributed (iid) N(0,σ^2_V), independent of the u_i. u_i is/are non-negative random variable(s), assumed to be independently and identically distributed as half-normal; $u_i \sim iidN^+(0, \sigma_u^2)$ [12,15].

Efficiency improvement is decomposed into technical and allocative efficiency [16]. Technical efficiency is based on input and output relationships. Technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible. Allocative inefficiency arises when the input mix is not consistent with cost minimization. Allocative inefficiency therefore occurs when farmers do not equalize marginal returns with true factor market prices.

2.2.2 Analytical framework

In analyzing efficiency, different models are used for the analysis. The most commonly employed models are the Cobb-Douglas and the translog production functional forms. The Cobb-Douglas function has limitations in terms of estimation of elasticities since it imposes a lot of restrictions. However, the Cobb-Douglas functional form has been extensively used due to ease of computation and simplicity. The Cobb-Douglas functional form is specified as follows:

$$Y = AX^{ai} \qquad 1$$

Where Y denotes output, "*A*" denotes technology, *X* refers to a vector of inputs and *ai* denotes parameter estimates.

This study however follows [17] and [2] that chose a translog algebraic function that is flexible. The use of the translog functional form for this study is because it places far fewer restrictions before estimation than the Cobb-Douglas, or Constant Elasticity of Substitution (CES) technologies.

The following translog stochastic frontier production function was used in this study

$$\ln Y_i = \beta_0 + \sum_i \beta_i \ln X_i + \sum_j \beta_j \ln X_j + \frac{1}{2}\sum_i \sum_i \beta_{ii} (\ln X_i)^2 + \frac{1}{2}\sum_j \sum_j \beta_{jj} (\ln X_j)^2 + \sum_i \sum_j \beta_{ij} \ln X_i \ln X_j + V_t - U_i \ldots\ldots 2$$

Where

Y_i denotes the total quantity of output (Kg).

X_i denotes a vector of input i and j are positive integers (i ≠ j =p 1,2,3…..)

β's are vector of parameters, $Vi's$ are assumed to be identical and independently distributed (iid) N(0, σ^2_V) and random errors independent of $Ui's$ and $Ui's$ are non-negative random variables called technical inefficiency effects. This is assumed to be independently distributed such that Ui is defined by the truncation at zero of the normal distribution with mean, Ui and variance, σ^2.

Considering the general formulation of the stochastic frontier production function in equation 2, the transformed empirical model is specified as follows:

$$LnOutput=\beta_0+\beta_1 lnFarmsize+\beta_2 lnLabour+\beta_3 lnFert+\beta_4 lnAgro+\beta_5 lnSeeds+0.5\beta_6 ln^2 Farmsize+0.5\beta_7 ln^2 Labour+0.5\beta_8 ln^2 Fert+0.5\beta_9 ln^2 Agro+0.5\beta_{10} ln^2 Seed+\beta_{11} lnFarmsize*lnLabour+\beta_{12} lnFarmsize*lnFert+\beta_{13} lnFarmsize*lnAgro+\beta_{14} lnFarmsize*lnSeed+\beta_{15} lnLabour*lnFert+\beta_{16} lnLabour*lnAgro+\beta_{17} lnLabour*lnSeed+\beta_{18} lnFert*lnAgro+\beta_{19} lnFert*lnseed+\beta_{20} lnAgro*lnSeed+e \ldots\ldots 3$$

where ln is the natural logarithm, lnOutput denotes the output of the ith farmer (kg), lnFarm size denotes the total number of hectares cultivated by a farmer, lnLabour is labour (mandays), lnFert is the quantity of chemical fertilizer applied(kg), lnAgro is other agrochemicals such as weedicides (litres) and lnSeed is the quantity of seeds used (kg). The β's are the coefficients that would be estimated and which measures the degree of output response to the respective input usage.

Technical efficiency (TE) of an individual firm is defined as the ratio of the observed output (Y_i) to the corresponding frontier output (Y^f_i), both in original units, and can be given as

$$TE = \frac{Y_i}{Y_i^f} = \frac{f(X_i;\beta)\exp(V_i - U_i)}{f(X_i;\beta)\exp(V_i)} = \exp(-U_i) \ldots\ldots 4$$

The measurement of firm-specific technical efficiency requires the estimation of the non-negative error (U_i) and the random normal error (V_i).

The parameters of the transformed translog production frontier as specified in equation 3.5 were estimated for the various farm groups using the maximum likelihood method in the FRONTIER econometric software. Given a flexible and interactive production frontier for which the translog production frontier is specified, the farm-specific technical efficiency (TE) of the j^{th} farmer was estimated by using the expectation of u_j conditional on the random variable e_j as shown by [18]. That is,

$$TE = exp(-U_j) = e^{-uj} \dots\dots\dots\dots\dots\dots\dots 5$$

So that 0 ≤ TE ≤ 1. Farm –specific technical inefficiency index (TI) was computed by using the expression below;

$$TI = (1 - exp\{-U_j\}) \dots\dots\dots\dots\dots\dots\dots 6$$

2.2.3 Estimation of allocative efficiency

Allocative efficiency is achieved when farmers are able to equalize their marginal value product to their input prices; the allocative index for a farm producing output j and using input i is shown below and follows what was used by [2].

$$MVP_i = P_j MPP = SiZi \dots\dots\dots\dots\dots\dots\dots 7$$

$$Z_i = {MVP_i}/{S_i} \dots\dots\dots\dots\dots\dots\dots 8$$

Where MVP_i is the marginal value product of input i, *MPP* is the marginal physical product of input *i*, S_i is the price of input *i*, P_j is the output price and Z_i is the allocative efficiency parameter of the input i.

$$MP_{ij} = \frac{Y_i}{X_i * E_{ij}} \dots\dots\dots\dots\dots\dots\dots 9$$

Where E_{ij} are the partial differentials (factor elasticities) of the translog function with respect to each of the variables in the function. Using the specification above as well as the output and input prices, the MVPs , MFCs and allocative efficiency ratios Z can then be derived using the equation below:

$$Z_i = MP_{ij} * \frac{P_y}{P_x} \dots\dots\dots\dots\dots\dots\dots 10$$

The analysis deals with the use of land, labour and fertilizer. The factor elasticities (E) and marginal products (MP) were calculated from the OLS estimates of the translog production function with respect to each farm group using equation 3. The factor elasticities for the pooled sample were computed from the equation for labour, land and fertilizer using the following: At this stage it is assumed you have not done the estimation.

2.2.3.1 Land

$E=\square lnOutput/\square lnlLabour=\beta_1+\beta_6 Farmsize+\beta_{11} lnLabour+\beta_{12} lnFert+\beta_{13} lnAgro+\beta_{14} lnSeed \dots 11$

2.2.3.2 Labour

$E=\square lnOutput/\square lnLabour=\beta_2+\beta_7 lnLabour+\beta_{11} lnFarmsize+\beta_{15} lnFert+\beta_{16} lnAgro+\beta_{17} lnSeed \dots 12$

2.2.3.3 Fertilizer

$$E=\partial lnOutput/\partial lnFert=\beta_3+\beta_8 lnFert+\beta_{12} lnFarmsize+\beta_{15} lnLabour+\beta_{18} lnAgro+\beta_{19} lnSeed\ldots\ldots 13$$

2.2.3.4 Agrochemicals

$$E=\partial lnOutput/\partial lnAgro=\beta_4+\beta_9 lnAgro+\beta_{13} lnFarmsiz+\beta_{16} lnLabour+\beta_{18} lnFert+\beta_{20} lnSeed\ldots\ldots 14$$

2.2.3.5 Seed

$$E=\partial lnOutput/\partial lnSeed=\beta_5+\beta_{10} lnSeed+\beta_{14} lnFarmsize+\beta_{17} lnLabour+\beta_{19} lnFert+\beta_{20} Agro\ldots\ldots 15$$

where lnLabour, lnFarmsize, lnFert, lnAgro and lnSeed are evaluated at their means. After obtaining the elasticities from the equation above, the marginal value product for the inputs was computed using the equation below:

$$MP_{ij} = \frac{Y_i}{X_{ij}} * E_{ij} \ldots\ldots 16$$

where Y and X represent arithmetic means (logs) of maize output of the ith farm group and the jth input for the jth farm group respectively, and E_{ij} is the factor elasticity of the ith output and jth input. Using the MP computed from the above as well as the input and output prices, the marginal value products (MVPs), marginal factor costs (MFCs) and the allocative efficiency ratios Z were then derived using the equation below:

$$Z_i = MP_{ij} * \frac{P_y}{P_x} \ldots\ldots 17$$

where P_y and P_x represent the unit price of output and input respectively.

The decision rule is based on the value of Z; if

Z = 1, then the factor input is efficiently utilized;
Z < 1 it implies the factor input is over utilized; and
Z > 1 it implies the factor input is underutilized.

2.2.4 Study area

The study was carried out in Nkoranza area of the BrongAhafo region of Ghana. The area is divided into Nkoranza North and Nkoranza South Districts. The area lies within longitudes 1^o 10’W and 1º 55’W and latitudes 7º 20N and 7º 55N covering a total land area of about 2300km^2. Agricultural land forms about 80% (1840km^2) of the total land area.

The area lies within the wet semi-equatorial region, having a mean annual rainfall level between 800-1200mm. The major rainy season in the area is from March to June, minor rains occur in September to November. The two rainy seasons demarcate a major and minor annual cropping season. The month of August experiences a short dry season, with the prolonged one in the months of December to March. Temperatures are generally high with an average annual temperature of 26ºC. The area is generally low lying, fairly drained and rising gradually from 153m-305m above sea level.

Nkoranza is within the forest savanna transition zone. It is predominantly an agricultural area where a lot of maize is grown. The transition zone is noted for the commercial production of maize in Ghana. Nkoranza is considered second to Ejura in the Ashanti region in terms of maize production. Maize production in the area is mainly for commercial purpose.

3. RESULTS

3.1 Empirical Estimation of Stochastic Frontier Production Function

The empirical estimate of the stochastic frontier which shows the best practice performance is presented in Table 1. Gamma is a measure of the level of inefficiency in the variance parameter (differences between observed output and frontier output actual) and ranges between 0 and 1. The gamma estimate 0.86, implies that 86 percent of random variation in maize production is actually due to inefficiency but not due to random shocks. This therefore suggests that about 14% of the variation in maize output is due to random shocks outside the farmer's control. Sigma squared of 0.56 is high and significant at 10% and therefore indicates the goodness of fit of the assumption of the distribution form. Thus, it indicates the appropriateness of the stochastic frontier model rather than the average response specifications. The mean technical efficiency in the study area is 91% indicating that farmers are operating at a level which is only 9% below the frontier.

Sigma-squared	0.56*
Gamma	0.86
Log likelihood function	-518.97
LR test of one sided error	23.81
Mean technical efficiency	0.91

Table 1. Maximum likelihood estimates of the stochastic frontier production function

Variable	Parameter	Coefficient	t-ratio
Constant	β_0	5.635	16.227***
lnFarmsize	β_1	3.628	8.119***
lnLabour	β_2	-0.342	-1.029
LnFert	β_3	1.721	3.730***
LnAgro	β_4	2.242	9.210***
LnSeed	β_5	0.861	2.154*
lnFarmsize * lnFarmsize	β_6	0.403	3.283***
lnLabour * LnLabour	β_7	0.043	0.534
lnFert * lnFert	β_8	-3.295	-3.594***
lnAgro * lnAgro	β_9	0.002	0.022
lnSeed * lnSeed	β_{10}	-0.408	-1.746*
lnFarmsize * lnLabour	β_{11}	0.117	1.599*
lnFarmsize * lnFert	β_{12}	0.590	3.195***
lnFarmsize * lnAgro	β_{13}	-0.344	-5.173***
lnFarmsize * lnSeed	β_{14}	-0.276	-2.099*
lnLabour * lnFert	β_{15}	-0.055	-2.809**
lnLabour * lnAgro	β_{16}	-0.178	-4.155***
lnLabour * lnSeed	β_{17}	1.090	1.032
ln Fert * lnAgro	β_{18}	-0.111	-3.346***
lnFert * lnSeed	β_{19}	0.006	0.189
lnAgroc* lnSeed	β_{20}	0.149	2.383*

*Source: Field Survey, 2009. ***, ** and * represent 1%, 5% and 10% level of significance, respectively.*

One added advantage of using a translog model is that, it makes it possible to analyze the cross effects of the variables used. Therefore using the parameter estimates of first order terms, the input elasticities were estimated. The researchers no longer interpret the coefficients as they were in the table above, but rather, explained the elasticities calculated. However, the second order terms indicates the interaction effect as well as the long run effect of these variables. This means that an interaction term with a positive coefficient means that these two inputs can be increased together in order to increase output. But in the case of a negative coefficient, an increase in one of the variables must be accompanied with a decrease in the other. Similarly, a positive significant of a squared term indicates that such variable could be increase in the long run while having a positive effect on output.

3.2 Input Elasticity

Determination of elasticities was necessary for the estimation of responsiveness of output to inputs. Most of the inputs on the stochastic frontier were statistically significant. However, the first-order coefficients of the translog production function are not taken as they are, because, they are not very informative. Rather, the input elasticities for each of the inputs calculated at the variable means are of interest [19]. The elasticities with respect to the inputs for the translog were computed using the sample means and equations 10,11,12,13 and 14.

Table 2 shows the results of the input elasticities for each input in the translog stochastic frontier production function. *Ceteris paribus*, a one percent increase in the area under maize cultivation will increase maize output by 5.3 percent. In addition a one percent increase in the quantity of labour employed in mandays, quantity of fertilizer applied, quantity of agrochemicals applied and the seed rate will increase output of maize by 2.1 percent, 16.2 percent, 1.1 percent and 5.9 percent respectively.

Table 2. Input elasticity

Variable	Elasticity
Farmsize	5.3
Labour	2.1
Fertilizer	16.2
Agrochemicals	1.1
Seeds	5.9

Source: Field survey, 2009

3.3 Determinants of Technical Efficiency

In this study technical efficiency is estimated by assessing the effects of farm and farmer characteristics on technical efficiency. Variables such as variety, education, gender, external support, household size, distance, and extension contacts were used to assess their effects on technical efficiency.

A negative sign on a parameter means that the variable increases technical efficiency, while a positive sign means that the variable reduces technical efficiency. The results in Table 3 reveal that sex of farmers, experience in maize farming and extension frequency have negative signs, and therefore increases technical efficiency. Distance and variety have a positive signs and thus reduce technical efficiency. The estimates of education and external support had the expected signs but statistically insignificant.
The estimate for experience is negative and significant; this suggests that the more experienced a farmer is the higher the chances of that farmer being more efficient. This can be explained by the fact that farming is done under risky environmental conditions such as

erratic rainfall, therefore, farmers who have cultivated the same crop over a long period of time are able to make accurate predictions on when to sow, the inputs to use, the quantity to use as well as the timing of the use of these inputs. These therefore make them more efficient in the use of these inputs as compared to inexperienced farmers. This finding is similar to findings of [20].

The coefficient of gender is negative and significant. This shows that male farmers are more efficient than female farmers. This could probably be explained by the fact that men have greater access to credit, probably because of cultural prejudice, and hence men are closer to the frontier. In addition, men are most likely to attend agricultural extension training seminars, [21]. The FAO estimates that, in Sub-Saharan Africa as a whole, 31 percent of rural households are headed by women, mainly because of the tendency of men to migrate to cities in search of wage labour. Despite this substantial role, women have less access to land than men. When women do own land, the land holding tends to be smaller and located in more marginal areas. Rural women also have less access to credit than men, which limits their ability to purchase seeds, fertilizers and other inputs needed to adopt new farming techniques. Only 5 percent of the resources provided through extension services in Africa are available to women, although in some cases, particularly in food production, African women handle 80 percent of the work (FAO, 2002) [22].

Table 3. Relationship between technical efficiency and farmer characteristics dependent variable: technical inefficiency index (1-exp {-uj})

Variable	Parameter	Coefficient	t-ratio
Constant	δ_0	-0.359	-1.592*
Variety	δ_1	0.372	2.937**
Education	δ_2	-0.009	- 0.715
External support	δ_3	-0.180	-0.434
Gender	δ_4	-0.337	-1.236*
Experience	δ_5	-0.010	-3.184***
Household size	δ_6	0.001	0.061
Distance	δ_7	0.004	2.029*
Extension frequency	δ_8	-0.039	-1.504*
Association membership	δ_9	0.237	0.556
Health status	δ_{10}	0.058	1.046

*Source: field survey, 2009. ***, ** and * represent 1%, 5% and 10% level of significance, respectively*

The variable capturing variety of maize is significant but positive. This did not meet the apriori expectation. The positive sign suggests that farmers using improved varieties of maize tend to decrease their level of efficiency. However, it is important to note that new technologies for that matter 'new variety' comes with its practices especially other complimentary inputs. For instance, the use of improve maize varieties does not produce the desired output, except fertilizer is used in combination. Not surprisingly, the farmers noted that the high cost of farm inputs especially fertilizer is their major plight. Similarly, this new practice that comes with improved varieties, in most cases, conflict with the farmers existing knowledge. This makes production processes more complex and farmers begin to mix up things.

The parameter estimate for "distance" is positive and significant. This suggests that farmers who spent more time in travelling from their residence to their farms have a lower efficiency. This could be explained by the fact that the more time a farmer spent in travelling to the farm the higher the probability of the farmer getting tired and thus less time will be available for farm work which in turn reduces efficiency. Similar conclusions were made by [23].

The negative and significant coefficient of extension frequency shows that farmers who have frequent contact with extension agents increase technical efficiency. Extension agents serve as communication links between researchers and farmers, thus transmitting new innovations from researchers to farmers; likewise sending farmers problems to researchers. Farmers who have contact with extension agents avail themselves to new innovations, techniques and practices and thus apply these to their farming activities and therefore enhances their efficiency. Other researchers that obtain similar findings are [24] and [25]. The “health status” of the farmer during the last cropping season has a positive sign. However, this relationship is not statistically significant. The positive sign suggests that ill-health of a farmer decreases the level of technical efficiency. This suggests that ill-health of a farmer reduces technical efficiency in maize production. Moreover, there is reallocation of income for the treatment of farmer.

3.4 Variety and Technical Efficiency by Districts

In Nkoranza traditional area, the maize planted is either improved variety or local variety. Table 4 shows that majority (57 %) of the farmers plant the local variety. This confirms [26]. According to the farmers they prefer the local variety because the local variety is able to produce with little rain and with or without fertilizer as compared to the improved variety which needs some form of special treatment before it can be productive. In addition traders who come from Accra to buy maize in the area prefer the local variety because the seeds are said to be smaller and would allow more grains to fill a bag as compared to improved varieties that have bigger grains.

Table 4 . Variety and Technical efficiency by districts

District	Variety	Frequency	Minimum	Maximum	Mean
Overall	Improved	86 (43 %)	0.39	0.98	0.87
Sample	Local	114 (57 %)	0.70	0.99	0.95
Nkoranza	Improved	40 (40 %)	0.51	0.94	0.70
North	Local	60 (60 %)	0.52	0.96	0.78
Nkoranza	Improved	46 (46 %)	0.23	0.99	0.73
South	Local	54 (54 %)	0.28	0.99	0.72

Source: Field Survey 2009

The results from Table 4 further suggest that farmers have higher technical efficiency in producing the local variety of maize as compared to the improved variety. The mean technical efficiency for the pooled sample is 0.87 and 0.95 for improved and local varieties, respectively. This indicates that farmers using the local variety are operating at technical efficiency of 5% below the frontier whereas farmers using the improved variety are operating at technical efficiency of 13% below the frontier. A similar trend is observed in Nkoranza North with mean technical efficiency of 0.70 and 0.78 for improved and local variety cultivators. In Nkoranza South, however, the mean technical efficiency of improved variety of 0.73 is slightly higher than those using the local variety with mean technical efficiency of 0.72. This could possibly be explained by the fact that most farmers in this area use the improved variety. Also, this area holds the old district capital and therefore farmers there had easy access to the district MoFA office where they could easily buy the improved seeds and access information regarding the cultivation of these varieties.

3.5 Equality of Means

A t-test was employed to further analyze the differences in the mean technical efficiencies of farmers who cultivate improved varieties and those who cultivate the local varieties to ascertain whether there is a significant difference between the mean technical efficiencies obtained. The null hypothesis (H_0) states that the mean technical efficiency of farmers cultivating the improved variety is the same for those cultivating the local variety. The hypothesis (H_a) states that the mean technical efficiency of farmers cultivating the improved variety is statistically different from that of farmers cultivating the local variety.

Table 5 outlines the results of the t-test. Assuming equal variance for improved and local varieties the mean difference between farmers using the improved variety and those using the local variety is -0.082 and is significant at one percent. This implies that there is statistical difference between the mean technical efficiency of farmers cultivating the improved variety and the local variety in Nkoranza North. The null hypothesis is therefore rejected. In Nkoranza South the mean difference between those cultivating the improved variety and those cultivating the local variety is 0.013, and this is significant at 10%; therefore, the alternative hypothesis is accepted that the mean technical efficiency of improved variety farmers is higher than their counterparts cultivating the local variety, the null hypothesis is rejected in favour of the alternative hypothesis.

Table 5. T-test for equality of means

District	Variety	N	Mean	T	Df	Sig. (2-tailed)	Mean Diff
North	Improved	40	0.70	-4.19	98.00	0.000***	-0.082
Nkoranza	Local	60	0.78				
South	Improved	46	0.73	0.34	98.00	0.7355*	0.013
Nkoranza	Local	54	0.72				
Pooled	Improved	86	0.87	-5.78	198.00	0.000***	-0.077
sample	Local	114	0.95				
North and	south improved	46	0.73	0.91	84.0044`	0.3675**	0.031
South	north improved	40	0.70				
North and	south local	54	0.72	-2.47	112.00	0.0155***	-0.063
South	north local	60	0.78				

*Source: Field Survey, 2009. ***, ** and * represent 1%, 5% and 10% levels of significance, respectively*

The mean difference between farmers cultivating the improved variety and farmers cultivating the local variety of the pooled sample is -0.077 and is significant at 1% suggesting that there is a statistical difference between farmers cultivating the improved and farmers cultivating the local varieties.

A t-test was also performed to compare the mean technical efficiency between cultivators of improved varieties in both districts and also cultivators of local varieties in the districts. The result shows that there exists a statistical difference between cultivators of improved variety in Nkoranza North and Nkoranza South with a mean difference of 0.377 and was significant at 10%. The mean difference between farmers cultivating the local variety in Nkoranza North and Nkoranza South was -0.063 and was significant at 5%.

3.6 Allocative Efficiency Estimation

Allocative efficiency is estimated in order to determine how maize farmers allocate inputs like labour, fertilizer and seeds. This analysis is carried out because the analysis of technical efficiency using the stochastic production frontier uses data on inputs and outputs and does not provide evidence on allocative efficiency; hence it cannot be used to draw inferences on total and economic efficiency. The results are based on separate regressions for each district and a pooled sample of the two districts. Allocative efficiency for land was not calculated because land is a fixed input and its needs scale adjustments depends on long-run profitability.

To determine the inputs allocative efficiency of farmers, marginal value products were computed for labour, fertilizer and seeds using equations 12, 13 and 14, using the OLS estimated coefficients of the translog production function. Table 6 shows that labour is being over utilized in Nkoranza north and south since the allocative efficiency ratios for both districts is below unity. Allocative efficiency ratio of 0.29 for the pooled sample signifies that labour is being over utilized in the study area. The allocative efficiency ratio of fertilizer is above unity for both Nkoranza North and South as well as for the overall sample. This indicates that fertilizer is being under-utilized in the two districts as well as the entire study area and thus, implies that farmers can still benefit from the use of fertilizer since they are still within the second stage of production. A possible explanation for the under-utilization of fertilizer could be due to the high cost of fertilizer since “input costs” was ranked by farmers as one of their most pressing problems of which fertilizer is a part.

Table 6. Marginal value products (MVPs), marginal factor costs (MFCs) and allocative efficiency ratios by districts

District	Variable	MVP	MFC	Z=MVP/MFC
Nkoranza North	Labour	101.73	550.90	0.18
(n=100)	Fertilizer	618.58	360.78	1.7
	Seeds	35.95	41.87	0.85
Nkoranza South	Labour	64.35	274.5	0.23
(n=100)	Fertilizer	2406.6	302.67	7.9
	Seeds	137.7	17.87	7.7
Total sample	Labour	124.2	416.04	0.29
(n=200)	Fertilizer	900.00	249.21	3.6
	Seeds	61.12	24.82	2.46

Source: field survey, 2009

From the table, seed is over utilized in Nkoranza north since the allocative efficiency ratio is less than unity. This could be due to the fact that most farmers were using the local variety of maize and possibly exceeded the seeding rate of 10kg/acre since they were not sure of how many of the seeds will germinate. Seed was, however, being underutilized in Nkoranza south since allocative efficiency ratio is above one. A possible explanation could be that more farmers in this district were using the improved varieties which are more expensive than the local variety. The allocative efficiency ratio for the pooled sample was 2.46 which are above unity. This signifies that farmers could still benefit from the use of seeds in the study area.

4. DISCUSSION

From the results above the factors that influence technical efficiency in the Nkoranza area are sex of farmer, experience in maize farming, extension frequency, distance and variety of maize. Sex of farmer, experience in maize farming and extension frequency increases technical efficiency whilst distance and variety reduce technical efficiency. One would have thought that farmers cultivating the improved varieties would be more efficient but from the study it is clear that farmers using the improved variety are less efficient. Improved varieties of maize come along with certain agronomic practices which farmers must follow in order to get the maximum level of potential output. However, this was not the case, farmers in Nkoranza ranked “high cost of inputs” as their most pressing problem and as such most of these farmers could not buy the recommended inputs that go with these improved varieties. In addition, the climatic conditions as well as cultural practices on the farm are very keen when planting improved variety of maize and if farmers are not able to meet these conditions they become inefficient.

It is often said that improvement of a country's human resource capacity for productivity is a pre-requisite for social and economic development. In the agricultural sector, both formal and non-formal education is essential for improving food security and rural employment and reducing poverty. Formal agricultural education is needed for the production of skilled manpower to serve the agricultural sector through extension, research, entrepreneurship and commerce.

The study shows that extension contact will improve maize production. In the study area the extension to farmer ratio is about 1:1500, this ratio is too large and therefore most farmers do not get the services provided by the extension agents. There is the need to train more extension agent to take care of the large farmer population. Also more females should be trained as extension officers to take care of the female farmers since most women will feel more comfortable to express themselves with their fellow counterparts. Extension agents should intensify farmer education on input use, and encourage farmers on group formation where they could interact and learn from each other. These groups could also serve as collateral for farmers to enable them obtain credit from credit institutions such as the banks.

The local variety of maize seeds was preferred by most farmers in the area and the t-test results affirms that there exist significant statistical differences in technical efficiency of people cultivating the local variety of maize and those cultivating the improved varieties. The study also found that the farmers underutilized seeds and fertilizer although these inputs have positive response to output. It is very crucial for farmers to adopt new varieties and farm management practices to improve on productivity and efficiency. The CSIR in collaboration with MoFA should conduct a research to find out why farmers prefer to still use the local variety despite the release of new varieties.

Lastly, the study reveals that farmers have high technical efficiency in producing the local varieties. Experience they say is the best teacher, as farmers have cultivated the local variety of maize over the years they tend to know much about it such that they know how and when to cultivate this variety under what conditions to get the maximum yields. This justifies that, continuous production of the crop makes the farmers become used to the production process and are able to improve on their productivity. Thus following the current supply-demand for maize in the area, one could simply argue that this will lead to a sustained balance between the two. However, this does not overrule the fact that farmers need to be educated and encouraged to cultivate the improved varieties since they are high yielding and early maturing. This could get production more regular and stable throughout the year.

5. CONCLUSION

The study provides evidence to show that the technical efficiency of maize farmers is significantly affected by sex of farmer, experience in maize farming, extension frequency, distance and variety of maize. Allocatively, farmers were found to underutilize seeds and fertilizer whilst labour was being over utilized. The onus is on government through MoFA to train more extension staff so that they can extend extension services to the large numbers of maize farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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