Cost structure of yam farmers in Ghana: The case of the forest savanna transition agro-ecological zone

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ABSTRACT

The study investigated the cost functions and the determinants of cost inefficiencies among yam farmers in Ghana using the stochastic frontier cost approach. The stochastic frontier cost approach estimates the general and inefficiency models simultaneously. Farm-level data and socio-economic variables on a sample of 374 yam farmers collected in 2009 in the Ashanti and Brong Ahafo regions were used in the study. The empirical results showed that cost of stakes and cost of seeds are the most important determinants of cost in the yam production process across the study communities. The cost of stakes was found to be significant in determining total cost. Planting cost constituted about 18 per cent of total costs. About 49.2 per cent of farmers sampled were producing on the cost curves higher than the average of the sample. The average inefficiency level generated was about 46 per cent higher than the minimum cost possible for the industry. The level of education of the farmer has a negative impact on farmer inefficiencies. The yield, which is the only output variable in the model had a positive impact on total cost with a coefficient less than 1, signifying an increasing return to scale. The area under cultivation had a mixed effect on inefficiency across regions, whilst there was no significant effect of the area under cultivation on cost in the Ashanti Region. Increasing area causes inefficiency and decline in the Brong Ahafo Region.

Introduction

The population of Ghana is growing between 2.3 per cent and 2.7 per cent per annum, with the addition of about 500,000 persons every year (National Population Council, 2006). However, the supply of food crops is not keeping pace with population growth. To fill the gap between food supply and demand, Ghana imports grains and other food items. Roots and tubers play a very important role in filling the gap, and also ensure food security in Ghana, especially, in the wake of the recent climate change and its attendant effects on crop production.

Yam is produced on 5 million hectares in about 47 countries in tropical and subtropical regions of the world. Yields are about 11 t ha^{-1} in the major producing countries of West Africa. According to IITA statistics, 48.7 million tonnes of yams were produced

worldwide in 2005, and 97 per cent of this was in sub-Saharan Africa. West and Central Africa account for about 94 per cent of world production. Ghana is the third leading producer of yams in the world (3.9 million tonnes) following Nigeria and Côte d'Ivoire (IITA, 2009).

According to Chamberlin (2007) agriculture in Ghana is overwhelmingly dominated by smallholders. Many commodities including cocoa, maize, and cassava are produced predominantly on small farms which are mostly inefficient. More than 70 per cent of Ghanaian farms are 3 ha or smaller in size. The smallest average holdings are in the south (2.3 ha at the coast *versus* 4.0 ha in the northern savanna).

Efficient production describes a relatively high level of productivity generated by specialisation, and an effective resource combination. Efficiency has three components; technical, allocative and economic. Technical efficiency can be defined as the ability to achieve a higher level of output, with a given level of production inputs. Technical efficiency measures how well a farm transforms inputs into outputs given the technology at its disposal (Kumbhakar & Lovell, 2000). Allocative efficiency has to do with the extent to which farmers make efficient decisions, by using inputs up to the level at which their marginal contribution to production value is equal to the unit factor cost at the level of production. Economic efficiency combines technical and allocative efficiency. It is possible for a firm to have either technical or allocative efficiency without having economic efficiency. Technical and allocative efficiencies are necessary, and when they do occur together, are sufficient conditions for achieving economic efficiency

(Yotopoulos & Nuggent, 1976). Efficiency is of great importance to prevent the waste of resources. Technically inefficient farmers fail to produce the maximum attainable output with the amount of inputs used and, therefore, can increase output with the existing level of inputs and available technology.

Ogundari & Ojo (2007) examined the effect of small scale crop production in Nigeria using the stochastic frontier approach, and found that food crop farmers are yet to achieve their best. This had been confirmed by the presence of both technical and allocative inefficiencies in their operations. Also, it was evident from the study that economic efficiency of the farmers could be improved substantially, and that technical inefficiency constitutes a more serious problem than allocative inefficiency. The study further showed that allocative efficiency appears to be more significant than technical efficiency as a source of gain in economic efficiency, meaning that allocative inefficiency is not a serious problem to the food crop farmers. That is, food crop farmers are capable of producing a given level of output at a minimum cost input ratio. The result, however, pointed to the importance of examining not only technical efficiency, but also allocative and economic efficiencies when measuring productive efficiency, with the aim of examining critically the role higher efficiency level can have on output in agriculture.

More recently, Okoye, Okorji & Asumugha (2009) employed a translog stochastic frontier cost function to measure the level of economic efficiency and it's determinants in small-holder cocoyam production in Anambra State, Nigeria. A total of 120 farmers were selected with a multistage random sampling technique using the

cost-route approach. Their study indicated that the cocoyam farmers in Anambra State are predominantly women who are not fully economically efficient. Individual levels of economic efficiency range between 10.20 per cent and 98.31 per cent with a mean of 59.42 per cent, which reveal substantial economic inefficiencies. Hence, there is considerable potential for enhanced profitability by reducing costs through improved efficiency. On average, by operating at full economic efficiency levels, cocoyam producers would be able to reduce their cost by 39.70 per cent depending on the method employed. Important factors indirectly related to economic efficiency were found to include age, education, farm size, farming experience and fertilizer use.

Oduol *et al*. (2006) examined the effect of farm size on the productive efficiency of 120 smallholder farms in land scarce Embu District of Kenya, using data envelopment analysis (DEA) to generate input oriented measures of productive efficiency from a 2004 cross-sectional survey data. The study targeted the effect of farm size on three components of productive efficiency, namely technical, scale, and allocative efficiency. The results suggested that gains from improving technical efficiency exist in all farm categories, although they appear to be much higher on large and on medium farms than on small farms. Whilst small farms tend to use land more intensively in an attempt to alleviate land constraints, the study suggested that the relatively high level of technical efficiency observed on small farms is mainly attributable to the adoption of traditional land saving techniques rather than the use of modern land saving technologies. Thus, the findings suggested that land scarcity in itself

is not sufficient to induce a desired level of technical efficiency.

Scale inefficiency is found to account for a larger share of technical inefficiency on small farms than on medium and on large farms, suggesting that increasing the scale of operation is necessary if the households have to reduce implicit labour costs and improve technical efficiency. Likewise, small farms are found to be less allocative efficient than medium and large farms. Nevertheless, gains from improving allocative efficiency exist in more than 90 per cent of the sample households.

Some of the underlying reasons for the low productive efficiency observed on the smallholder farms include shortage of rental land, as every household tries to eke out a living from land. Poorly functioning or absence of land rental markets, and lack of working capital due to low capital accumulation, and lack of access to credit.

Tchale (2009) used the stochastic frontier approach to study smallholder agriculture in Malawi, and the results of the study showed that allocative or cost inefficiency is higher than technical inefficiency. The low economic efficiency level can largely be explained by the low level of allocative efficiency relative to technical efficiency. High levels of cost inefficiency are probably attributable to the low profitability that results from inadequate agricultural market development. Some significant determinants of efficiency were access to markets, access to extension service especially that related to crop production, and the use of fertilizer and improved seed varieties. The results also indicated the importance of area-specific biophysical properties in production efficiency. For example, the significance of the water

requirement index (WRI) highlights the importance of greater investments in drought risk management instruments, given smallholder farmers' very high reliance on rainfall.

The problems of small-scale agriculture include the use of traditional technology of low productivity, extension services that are inadequately funded, and poor distribution of agricultural inputs. The resources that are employed by yam farmers include land, seed yams, herbicides, labour and stakes. Not much studies has been done on the efficiency or otherwise of the use of these inputs in yam production in Ghana. Most of the studies on yam production in Ghana have focused on agronomic issues (Otoo *et al.*, 2005).

The objectives of the study, therefore, were to examine the economic efficiency of yam production in the forest savanna transition agro-ecological zone of Ghana and to identify the sources of inefficiency among small-scale yam farmers.

Materials and methods

Study area

The study was conducted in the forest-savanna transition agro-ecological zone in Ghana. The zone is one of the major yam growing areas, and is the area where yam is cultivated most in Ghana. Most parts of the zone is in the Brong Ahafo Region and extends to the Ashanti Region. Four districts, based on the intensity of yam production, were selected purposively for the study. These districts were the Kintampo North, Nkoranza and Atebubu/Amantin in the Brong Ahafo Region and Ejura Sekyedumasi District in the Ashanti Region.

Yam is one of the most important food security and cash crop in this part of the country. It also has the major yam markets in the country. Most of the yam exported to neighbouring countries is produced in the study area. Yam is so important in the study area to the extent that it is the only crop that is celebrated annually by the inhabitants. There are vast tracts of farmland suitable for the production of the crop. Commonly cultivated crops apart from yam include cassava, millet, sorghum, cowpea, rice, groundnut, watermelon, cashew, mango and tobacco.

Data collection and sampling procedure

Primary data were collected from 374 respondents using a structured questionnaire. Data collected include respondents' socio economic characteristics such as age, household size, sex and educational level, land management techniques, yield, family labour, farm size and problems constraining yam production activities.

Some of the farmers had the opportunity of visiting a vine technique demonstration field whilst others did not. In assessing their willingness to adopt the technique, a thorough description of the technique was made with a strand of vine and a medium after which farmers were asked whether they are willing to adopt the technique or not.

The field survey was carried out between September and October 2009. Multi-stage sampling technique was employed to select the sample points. In order to ensure some distinct variation in the ecology of the survey locations, four major yam-producing districts were purposively selected from the zone.

Ten rural communities were then randomly selected in each district. From the list of yam growers obtained in each community,

between five and 10 respondents were then chosen, using simple random sampling technique, and in proportion to the total number of yam farmers in the communities. A total of 374 respondents were interviewed.

Theoretical framework

A number of alternative approaches are used to measure productive efficiency. The original approaches are based on what are called frontiers, as proposed by Farrell (1957). A frontier defines the maximum feasible output in an environment characterised by a given set of random factors (Tchale, 2009). The ratio of the observed output to the frontier is taken as a conventional measure of its relative efficiency. Two types of frontiers have been used in empirical estimations; parametric and non-parametric frontiers. The former uses econometric approaches to make assumptions about the error terms in the data generation process and also imposes functional forms on the production functions, whilst the latter neither imposes any functional form nor makes assumptions about the error terms. The parametric approach essentially implies that structural restrictions are imposed, and the effects of misspecification of the functional form might be confounded with the inefficiency. Tchale (2009) noted that non-parametric approaches (data envelopement analysis – DEA) are free from misspecification, but they do not account for the effect of other factors that are normally not under the control of the farmer and, thus, are not good for studying efficiency at the smallholder farmer level where conditions are highly heterogeneous.

The stochastic frontier modelling is becoming increasingly popular because of its flexibility and ability to closely marry economic concepts with modelling reality (Ogundari & Ojo 2007). The modelling, estimation and application of stochastic frontier production function to economic analysis assumed prominence in econometrics and applied economic analysis following Farrell's (1957) seminar paper, where he introduced a methodology to measure technical, allocative and economic efficiency of a firm. According to Farrell (1957), technical efficiency is associated with the ability of a firm to produce on the isoquant frontier, whilst allocative efficiency refers to the ability of a firm to produce at a given level of output using the cost-minimising input ratios .Thus, defining economic efficiency as the capacity of a firm to produce a predetermined quantity output at a minimum cost for a given level of technology (Bravo-Ureta & Pinheiro, 1997).

However, the modelling and estimation of stochastic frontier production function has been a subject of considerable interest in econometrics and applied economic analysis during the last two decades. Review of frontier production are given by Forsund, Lovell & Schmidt (1980) and Battese & Coelli (1992). The Stochastic frontier production proposed by Battese & Coelli (1992) assumed that a random sample of farms is observed over T period such that the production of the N farms over time is a given function of input variables and random variables, which involve the traditional random error and non-negative random variables, which are associated with technical inefficiencies of production. One of the earliest empirical studies in stochastic frontier production function was an analysis of the sources of technical inefficiency in the Indonesian

wheat industry by Pit & Lee (1983). The study estimated a stochastic frontier production function by the method of maximum likelihood, and the prediction of technical inefficiencies were then regressed upon size of firm, age and ownership structure of each firm. These variables were found to have significant effect on the degree of technical inefficiency of the firms.

This study follows closely the approach used by Paudel & Matsuoka (2009) in analysing the cost efficiency of maize farmers in Nepal. Aigner, Lovell & Schmidt (1992), Meeusen & van den Broeck (1997) independently introduced the stochastic production or cost frontier models. Suppose that a producer has a production function $f(z_i,\beta)$, in the production characterised by efficiency, the ith firm would produce;

$$q_i = f(z_i,\beta) \tag{1}$$

where q_i is the scalar output of producer i, z_i is the vector of N inputs used by producer i, $f(z_i,\beta)$ is the production frontier and β is the vector of technology parameters to be estimated. Stochastic frontier analysis assumes that each firm potentially produces less than it could due to the degree of inefficiency. Specifically, the above equation can be written as;

$$q_i = f(z_i,\beta)\varepsilon_i \tag{2}$$

where ε_i is the level of efficiency for firm i.

Since the output is assumed to be strictly positive ($q_i > 0$), ε_i must be in the interval (0, 1). If $\varepsilon_i = 1$, the firm is achieving the optimal output with the technology embodied in the production function $f(z_i,\beta)$. When $\varepsilon_i < 1$, the firm is not making the most of the inputs

z_i given the technology embodied in the production function $f(z_i,\beta)$. Output is also assumed to be subject to random shocks, implying that;

$$q_i = f(z_i,\beta)\varepsilon_i exp(u_i) \tag{3}$$

where u_i is the one-sided disturbance form used to represent cost inefficiency. Taking the natural logarithm for equation 3 on both sides yields;

$$ln(q_i) = ln\{f(z_i,\beta)\}+ln(\varepsilon_i)+u_i \tag{4}$$

Assuming that there are k inputs and that the production function is linear in logs, defining $u_i = - ln(\varepsilon_i)$, yield can be expressed as;

$$ln(q_i) = \beta_0+\sum_{j=1}^{k} ln(z_{ji})+v_i-u_i \tag{5}$$

Since u_i is subtracted from $ln(q_i)$, restricting $u_i \geq 0$ implies that $0 < \varepsilon_i \leq 1$, as specified above.

Kumbhakar & Lovell (2000) also provided a detailed version of the above derivation, and showed that performing an analogous derivation in the dual cost function problem allows for specifying the problem as;

$$Ln(c_i) = \beta_0+\beta_q ln(q_i)+ \sum_{j=1}^{k} ln(z_{ji})+v_i-u \tag{6}$$

where q_i is output, z_{ji} is input quantities, c_i is cost and p_{ji} is input prices.

To analyse the data, both the statistical and tabular methods as followed by Paudel & Matsuoka (2009) were employed. For the purpose of the statistical analysis, the Battese & Coelli (1995) model was used to specify a stochastic frontier cost function with the behaviour inefficiency component

to estimate all parameters together in the one step maximum likelihood estimation. This model is implicitly expressed as;

$$\ln C_i = g(P_i, Y_i; \alpha) + (V_i + U_i) \qquad (7)$$

where C_i represents the total cost of production, g is a suitable functional form such as the Cobb-Douglas, P_i is the vector variable of input prices such as machinery, animal power, labour, chemical fertilizers, manure, pesticides and seeds, Y_i is the value of maize produced in kg and α is the parameter to be estimated. The systematic component V_i represents the random disturbance costs due to the factors outside the scope of farmers. It is assumed to be identical and normally distributed with zero mean and constant variance as $N(0, \sigma_2 v)$. U_i is the one-sided disturbance form used to represent cost inefficiency and is independent of V_i. Thus, $U_i = 0$ for a farm whose cost lies on the frontier, $U_i > 0$ for farms whose cost is above the frontier, $U_i < 0$ for farms whose cost lies below the frontier. The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase cost.

The cost efficiency of an individual yam farm is defined in terms of the ratio of the observed cost (Cb) to the corresponding minimum cost (Cmin). The available Technology Cost Efficiency is expressed as;

$$= \frac{Cb}{Cmin} = \frac{g(P_i, Y_i; \alpha) + (V_i + U_i)}{g(P_i, Y_i; \alpha) + (V_i)} \exp U_i \quad (8)$$

where the observed cost (Cb) represents the actual production cost, whereas the minimum cost (Cmin) represents the frontier total production cost or the least total production cost level. Cost efficiency takes the values from 1 or higher, with 1 defining cost efficient farm (Ogundari & Ojo, 2006). The inefficiency model (U_i) is defined as:

$$U_i = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} \qquad (9)$$

where Z_1, Z_2, Z_3, Z_4, Z_5, and Z_6 represent the area cultivated to yam, technology adoption, treatment, age of the FBO member, gender of the FBO member and education of FBO member.

The socio-economic variables are included in the model to indicate their possible influence on the cost efficiency of the yam farms. The variance of the random error $\sigma_2 v$ and that of the cost inefficiency effects $\sigma_2 u$ and the overall variance of the model σ_2 are related as: $\gamma = \sigma_2 u / \sigma_2 v + \sigma_2 u$, where γ measures the total variation of the total cost of production from the frontier cost which can be attributed to cost inefficiency (Paudel & Matsuoka, 2009). Hence, following the adoption of Battese & Coelli (1995) and Paudel & Matsuoka (2009) framework for the analysis of the data, the explicit Cobb-Douglas functional form for the yam farms across the study area is specified as;

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \alpha_5 \ln P_{5i} + \alpha_6 Y_i + (V_i + U_i) \qquad (10)$$

where C_i represents the total production cost in GH¢; P_1 represents the cost of labour per farm in GH¢, P_2 represents the cost of agro-chemicals per farm in GH¢, P_3 represents land rent in GH¢, P_4 represents the cost of seeds in GH¢ per farm and Y_i represents the output of yam in kg. To make the case self-

dual, the Cobb-Douglas functional form is chosen in order to satisfy the requirements of the cost function upon which the analysis is based. Scale effect (SE) is mathematically defined as inverse of the sum of all cost elasticities with respect to all output included in the regression (Paudel & Matsuoka, 2009).

The estimated cost function parameter, most especially the coefficients of the output for the Cobb-Douglas model, suggests the presence of scale effects (SE) in the production process. Positive economies of scale (ESp) prevail, if the SE is greater than 1 (ESp is defined as the reduction in cost of production of the given output level whilst holding all other input prices constant) and, conversely, the diseconomies of scale (DS) when the SE is less than 1. The return-to-scale and scale effects are equivalent measures if and only if the product is homothetic, an assumption that applies to and is implicit in the Cobb-Douglas function structures (Paudel & Matsuoka, 2009). If costs increase proportionately with output, there are no economies of scale, meaning that there is a constant return-to-scale. If costs increase by a greater amount than output, there are diseconomies of scale, meaning that there is a decreasing return-to-scale. If costs increase by a lesser amount than the output, there are positive economies of scale or simply as economies of scale meaning increasing return-to-scale. Here, since the Cobb-Douglas function was used, these assumptions are imposed. The estimate for all the parameters of the stochastic frontier cost function, and the inefficiency model are simultaneously obtained using the computer program, STATA.

Results and discussion

A total of 374 farmers in two regions (Ashanti – 102, Brong Ahafo – 272), and who cultivated yam in the season under review were studied.

A total of 86.4 per cent of these farmers were males and 13.6 per cent were females (Fig. 1.) This signifies that the yam farmers in the sample under study are male dominated. Two hundred and thirty (61.33%) out of the 374 farmers have been to school, whilst 144 (38.67%) of them have never been to school. In general, the average years of schooling for the farmers is 8.37 and is slightly higher in the Brong Ahafo Region (8.80) than in the Ashanti Region (7.22). The mean age of a yam farmer is 41.25 years with slight regional differences. About eight out of 10 of all the yam farmers are married and the average household size of these farmers is eight.

On average, yam farmers interviewed in the study were in their early forties and have had at least 8 years of formal schooling. About eight out of every 10 of the yam farmers were married and formed part of a household which had close to nine members on average (Table 1).

One important measure of the scale of production is the land area cultivated by the farmer. Table 2 gives an idea of the average farm sizes cultivated by the farmers in the two regions. The farm size ranges between one and four hectares with a greater proportion of the farmers (32.09 %) cultivating less than one hectare.

Fig. 2 further shows that cost of stakes and seed cost are by far the highest contributing items to total cost. The summary statistics of variables used in the stochastic frontier
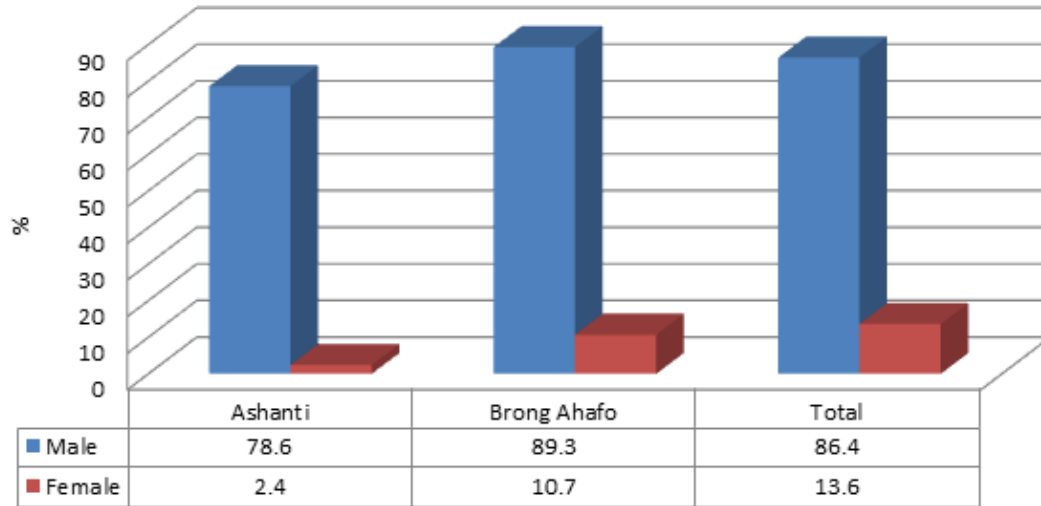
Fig. 1. Gender of yam producing farmers in the study sample by region (%)

model are presented in Table 3, which shows means of the production variables. The cost of production is calculated in GH¢ per farmer for each of the variables for the crop production year 2009. As shown in Table 3, the average total cost of GH¢392.32 was required to produce, on average, 1083.57 tubers of yam per hectare. Among the various factors of production, the cost of seeds (seed yam) and cost of stakes accounted for the highest share (about 27% each) followed by the cost of labour for weeding (19.9%) and then by the cost of agro-chemicals (weedicides) used in the production, (7.9%). The farmer spent an average of GH¢97.42 on stakes, GH¢96.97 on seed yams, GH¢71.48 on labour for weeding, GH¢64.93 on labour for planting and GH¢28.22 on weedicides (Table 3).

Estimates of the stochastic frontier cost function parameters (all zones together)

The results of the maximum-likelihood (ML) estimates of the parameters of the sto-

TABLE 1

Farmer Demographic Characteristics in the Study Area

Variables	*AR*	*BA*	*All*
Sample size	102	272	374
Mean age	38.39	42.33	41.25
Years of schooling	7.22	8.80	8.37
Proportion married	0.75	0.80	0.79
Household size	7.66	8.83	8.50

TABLE 2

Distribution of Plot Sizes

Yam area (ha)	*AR %*	*BA %*	*All %*	*Total frequency*
Less than 1	29.41	33.09	32.09	120
1 to 1.9	10.78	8.82	9.36	35
2 to 2.9	22.55	22.43	22.46	84
3 to 3.9	18.63	19.85	19.52	73
4 and above	18.63	15.81	16.58	63

chastic cost frontier models are presented in Table 4. All the estimated independent variables had expected positive signs; the
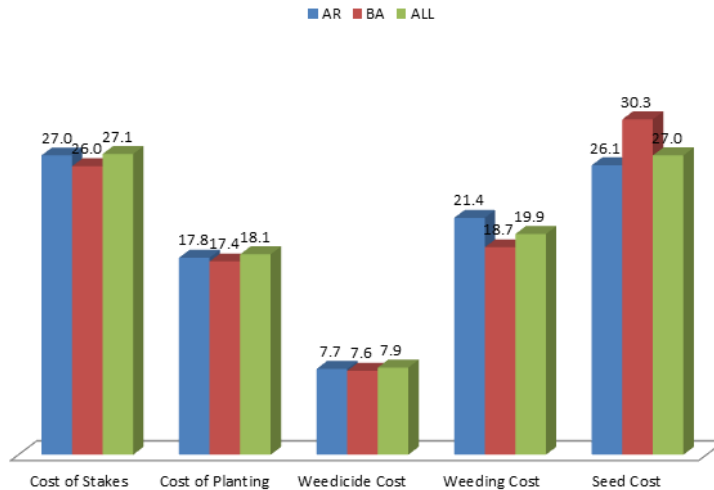
Fig. 2. Percentage contribution of various costs to total cost

TABLE 3

Production Cost Components of Yam in the Study Regions

	AR	*BA*	*All*
Area (ha)	2.36	2.25	2.28
Cost of stakes per ha (GH¢)	100.81	96.14	97.42
Cost of planting per ha (GH¢)	66.33	64.4	64.93
Weedicide cost per ha (GH¢)	28.91	27.96	28.22
Weeding cost per ha (GH¢)	79.77	69.11	71.48
Seed cost per ha (GH¢)	97.49	111.77	96.97
Total cost per ha (GH¢)	401.94	388.71	392.32
Yield per ha (Tuber)	1000.52	1118.7	1083.57

weeding cost also affects total cost. The remaining cost variables, though not statistically significant, influences the total cost positively (Table 4). Hence, these variables are important determinants of the cost of yam production across the two regions. The reason why weeding and weedicides cost were insignificant determinant of total cost may be because most farmers do not use weedicides on yam farms, and the few who do were unable to quantify the total cost properly since it was based purely on memory recall.

Since the cost function is the total for all input prices, the percentage increase in the total production cost was based on the interpretation of the coefficient of Cobb-Douglas function as the elasticity of production. In this case, the coefficients of the cost function serve as the cost elasticity of production. Hence, a one per cent increase in the cost of stakes will increase the total production cost by approximately 0.16 per cent, a one per cent increase in the weeding cost will increase the total production cost by approximately 0.25 per cent. Though not significant, a one per cent increase in the cost of planting will increase the production cost by approximately 0.07 per cent.

coefficients of cost of stakes, planting cost, cost of weedicides, land rent, weeding cost and yam output. This suggests that there is conformity with the assumption that the cost function monotonically increases with the input prices.

The statistical significance of the parameter estimates of the frontier cost function show that for the two regions, at one per cent significance level, the coefficients of yield and stake cost have positive effects on total cost. At five per cent significant level, the

Maximum-Likelihood Estimates of Parameters of the Cobb-Douglass Frontier Function for Yam Farmers, in the Study Area

	Estimates 1 (All)	Estimates 2 (AR)	Estimates 3 (BA)
Observations	374	102	272
General model			
Constant	3.170***(0.1268)	2.933(0.2491)	3.103(0.1846)
Yield	0.0003***(0.0002)	0.0003***(0.00003)	0.0004***(0.00002)
Stake cost	0.1674*(0.1005)	0.5419***(0.0656)	0.4819***(0.0447)
Planting cost	0.0651(0.1127)	0.2852(0.2242)	0.1015(0.1387)
Weedicide cost	0.0003(0.0083)	0.0077(0.0205)	0.0026(0.0091)
Weeding cost	0.2557**(0.1352)	0.2997(0.2427)	0.1009(0.1445)
Inefficiency model			
Constant	-0.6102(0.5931)	-10.9024(5.6576)	0.0582(0.0903)
Yam area	-0.2218(0.1738)	2.287**(1.043)	-4.0429***(0.7618)
Years of schooling	-0.1108**(0.0482)	-0.3337**(0.2368)	0.0582(0.9829)
Diagnostic statistics			Chi Square
1055.27***	890.22***	2244.37***	
Log likelihood function	29.04	10.01	48.9
Sigma square	0.1488		
Gamma	22.31***		

Standard errors are in parentheses. Significance level: 1 % (***), 5 % (**), 10 % (*)

In the respective regions, however, some differences in the level of effect of these input costs on the total cost of yam production were observed. For instance, though total yam output in tubers had a positive effect on total cost, in both regions, the magnitude of effect was higher in the Brong Ahafo than in the Ashanti Region.

Cost efficiency

The main purpose of the cost function model is to analyse the cost efficiency of the yam farms in the study area. So, the model is assumed to be the representation of the data for considering its highly significant chi-square value, as well as the log likelihood function under the half normal distribution assumed with maximum likelihood techniques. The cost efficiency analysis showed inefficiency effects in yam production as confirmed by a significant gamma value of 22.31 at 99 per cent confidence level (Table 5). This implies that about 22 per cent of the variation in the total cost of production among sampled farmers was due to the differences in the cost efficiency. That is, more than one-fifth of observed differences among farmers' production cost were due to cost inefficiency.

The post estimation predicted cost efficiencies ranged from four to nine as shown in Fig. 3. The mean cost efficiency of an average yam farm was estimated at 5.87 whilst the minimum cost curve possible was 4.018 (Table 5). This suggests that an average yam farm across the two regions incurred cost that are about 46.07 per cent above the minimum cost defined by the frontier.

That is, about 46.07 per cent of the yam farms' costs are wasted in comparison to the

Efficiency level	Frequency	Relative efficiency
4.0 to 4.4	20	5.35
4.5 to 4.9	52	13.9
5.0 to 5.4	55	14.71
5.5 to 5.9	63	16.84
6.0 to 6.4	88	23.53
6.5 to 6.9	56	14.97
7.0 to 7.4	27	7.22
7.5 to 9	13	3.48
Total	374	100
Mean		5.87
SD		0.902
Minimum		4.018
Maximum		9.208

curve lies below or within this range). Thus, over 49 per cent of farms are spending more to produce at the same average level of output of other farms in the industry. This indicates that an appreciable number of farms need to minimise the waste of resources associated with yam production process.

These results, however, lie between those obtained by Paudel & Matsuoka (2009), who found out that majority of maize (another important staple) farms were inefficient in Nepal among a predominantly uneducated farming population, and that obtained by Ogundari & Ojo (2006), who analysing the small scale maize production in Nigeria, found that a relatively larger proportion of farms were fairly efficient in terms of minimising production cost. Ogundari & Ojo (2006) explained that a greater proportion of their sampled farmers had high levels of education, and might have accounted for the low incidence of cost inefficiency. Most of the farmers sampled have had about 8 years of formal schooling and lie between the range of those used by Paudel & Matsuoka (2009) and Ogundari & Ojo (2006).
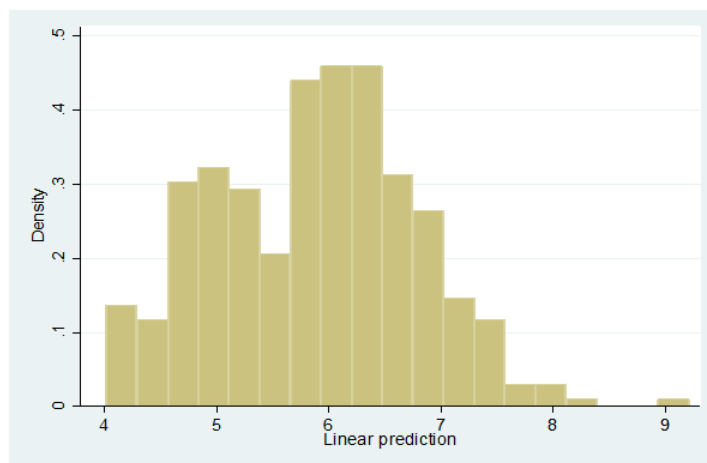
best practice farms producing the same output of yam and using similar technologies. Put simply, an average farm in the sample is spending an extra 46 GHp on an activity that best practice farms use GH¢1.00. The higher value of cost inefficiency represents the more inefficient farms. The frequencies of the average cost efficiency scores range between 4.0 and 5.9, representing about 50.80 per cent of the sample (farmers whose cost

Fig. 3: Cost efficiency in the study area

Determinants of cost inefficiency

Table 4 shows the results of the inefficiency analysis. The signs and explanatory variables shown have important implication on the cost efficiency of yam production. In the estimation for all the regions, the years of schooling of the farmer had negative effects on cost inefficiency. This implies

that an additional year in school could help reduce inefficiencies by about 11 per cent. Specific to the regions, an additional year of schooling helped reduced inefficiency in Ashanti by about 33 per cent. In the Brong Ahafo Region, increasing years of schooling did not have a significant effect on inefficiency. Further, increasing the area under cultivation to yam generally increases cost inefficiency and this is significant at five per cent. In the Brong Ahafo Region, however, increasing farm sizes have a negative effect on the incremental cost inefficiencies, thus, larger farms are more likely to be cost efficient, the opposite is the case for the Ashanti Region. A likely explanation for this may lie in the availability of labour. In the Brong Ahafo Region, household sizes (8.83) are higher than in the Ashanti Region (7.66). Assuming family labour is the main source of farm hands, then farming households in the Brong Ahafo Region can conveniently increase area under cultivation without incurring as much labour cost as those in the Ashanti Region will.

Scale effects

The scale effects among the yam farmers in the two regions together were computed as the inverse coefficient of cost elasticities with respect to the yam output in tubers since it is the only output variable in the analysis. The computed value of scale effect is 3333.33 (i.e. 1/0.0003). This confirms that there is a positive economy of scale. The computed value of scale effect is greater than 1, meaning that any increase in the total production cost will increase the total yam production. The result obtained is an indication that there are positive economies of scale, and that yam farmers in the study area experience a decrease in the total production cost irrespective of the area of yam production. It indicates that yam farmers are experiencing an increasing return to scale. On regional basis, the fore going in terms of the scale effect still holds.

Conclusion and recommendations

Yam plays an important role in the socio-economic and political aspect of the production and consumption decisions in Ghana. With the economy growing, there is a gradual shift from subsistence cultivation of the crop to market-oriented production systems. For the farmers to compete and find market for their yam produce, they must be price competitive. It is, however, impossible, all things being equal, for the rational farmer to sell his produce below the cost of production. Thus, if any gains are to be made in terms of reducing the price at which the farmer sells his yam, it will require efforts directed toward using inputs efficiently in order to reduce the cost of production. From the study, the important inputs contributing to the cost of production of yam are the seed cost and the cost of stakes. Also, an important determinant in reducing cost inefficiency is the level of formal education of the farmer especially in the Ashanti Region. In the Brong Ahafo Region, bigger farms are likely to reduce inefficiency.

For policy purposes, the study recommends that efforts by extension agents should be geared toward encouraging farmers to send their kids (who are likely to take over these farms) to school, and also encourage them to cultivate parcels that they can adequately maintain. Where possible, in the Brong Ahafo Region, large scale farms should be encouraged.

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