academicJournals

Vol.8(6), pp. 99-110, June 2016
DOI: 10.5897/JAERD2016.0765
Articles Number: 9FAB53758749
ISSN 2141-2170

http://www.academicjournals.org/JAERD

Journal of Agricultural Extension and Rural Development

Full Length Research Paper

Efficiency of chili pepper production in the volta region of Ghana

Jacob Asravor[1]*, Edward E. Onumah[2] and Yaw B. Osei-Asare[2]

[1]Institute of Agricultural Economics and Social Sciences in the Tropics and Subtropics, University of Hohenheim, Germany.
[2]Department of Agricultural Economics and Agribusiness, University of Ghana, Ghana.

Received 20 January, 2016; Accepted 29 April, 2016

This study investigates the overall economic efficiency of chili pepper producers in the Volta region of Ghana. The study used farm level data to examine the productivity of selected agricultural inputs, technical, allocative and economic efficiency levels and the determinants of efficiency of chili pepper production. The modified translog stochastic frontier production and cost function models were adopted for the study using the maximum likelihood estimation procedure. Data was collected on 200 chili pepper producers through a multi-stage sampling technique. The results indicate that on average, chili farms were only 65.76% economically efficient, whilst mean technical and allocative efficiencies were estimated to be 70.97% and 92.65%, respectively. The findings also reveal that chili farms in the study are characterized by decreasing returns to scale. The results further show that age, experience and gender among others significantly influence technical efficiency. Allocative efficiency is however influenced by gender, education and access to credit inter alia. The joint effect of these variables explains the variation in the economic efficiency of the chili farms. The study therefore concludes that chili farms in the study area are economically less efficient. The study recommends policies and programs that aim at attracting the teaming youth into chili pepper cultivation to be pursued by giving them incentive packages. Experienced chili farmers are advised by the study not to solely rely on their know-how but should endeavour to complement their knowledge with advisory services given by extension officers. Policy makers should also focus on policies that will facilitate chili farmers' access to low interest bank loans in the form of inputs.

Key words: Stochastic frontier, modified translog model, maximum likelihood estimation, multi-stage sampling technique, chili pepper production.

INTRODUCTION

Vegetable cultivation in both rural and urban Ghana is a germane economic activity. This is because of its importance as a major source of quick employment and income generation for both the rural and urban poor.

***Corresponding author. E-mail: j.asravor@uni-hohenheim.de; djgharo@gmail.com.**

Vegetable farming has the potential to alleviate poverty and improve food security in Ghana. According to the AVRDC (2006), vegetable farming provides smallholder farmers with much higher income and more jobs per hectare than staple crops. Chili pepper (*Capsicum annuum*) is an important high value cash crop in Ghana and it is largely cultivated for export and domestic consumption by both the urban and rural poor. Its cultivation and consumption has long been part of Ghana's agriculture and diet (MiDA, 2010). Chili pepper is called "green gold" by some farmers because of its economic value to them. Chilies produced in Ghana are known for their good reputation in the European markets in contrast to chilies from other parts of the world especially the Legon 18 variety which has become famous for its great taste and longer shelf-life. The Bird's Eye chili variety furthermore offers an emerging opportunity for higher value chili exports in Ghana (MiDA, 2010). Chilies are the fourth most harvested crop in Ghana after cassava, plantain and yam with about 984,586 households engaging in its cultivation (GSS, 2014).

Ghana has been identified to have both comparative and competitive advantages over other African countries in terms of chili pepper production. Despite these advantages, the country is currently ranked fourth in chili production in Africa after Egypt, Nigeria and Algeria (MiDA, 2010). The world's chili demand is on the ascendancy and this continuous increase in demand means that the world's chili production still has space for improvement, through increasing land productivity and raising its yield potentials. In fact, enormous yield gaps which are still rife on chili farms need to be improved. Presently, the average yield of chili pepper in Ghana is 8.30 Mt/ha which is far below the achievable yield of 32.30 Mt/ha (MoFA, 2014). Improvement in yield is therefore a necessity and needs to be pursued with all the resources it requires for efficient production.

Knowledge of the overall productive efficiency status and its determinants, in addition to the key drivers of productivity of chili farms are relevant from policy perspective in a country where new technologies are scarce and productive resources are inadequate. This is because, gains in the efficiency and productivity of chili farms are essential for increasing the farm income of both the rural and urban dwellers who are engaged in its cultivation. The challenge of low productivity on Ghanaian chili farms can be attributed to some key constraints militating against the attainment of the potential frontier output. Such constraints may include the attack of pests and diseases, limited land, poor prices of produce, low adoption of improved chili pepper cultivation technologies and inefficiencies arising from the allocation of production resources. This implies that efforts at improving the productivity of chili farms cannot overlook identifying and addressing these key factors. As a result of the lack of access to productive resources, coupled with the low rate of adoption of improved chili production technologies in Ghana, improvement in the efficiency of chili farms has become paramount for enhancing the productivity level of chili farms. Although a plethora of efficiency studies on Ghana's agricultural production exist in the literature, much of these studies focus on technical rather than allocative and economic efficiencies. However, it is only through substantial gains in overall economic efficiency that significant gains in output can be achieved (Bravo-Ureta and Pinheiro, 1993). The need to boost the productivity and efficiency status of chili farmers in Ghana has led to the following research questions; what are the current levels of technical, allocative and economic efficiencies and what are the major determinants of inefficiency of chili farms in the Volta region of Ghana?

MATERIALS AND METHODS

Study area and data collection

The study considered a cross sectional data from four districts in the Volta region of Ghana. The Volta region is endowed with abundant water resources which make all year-round production of vegetables possible. A multi-stage sampling technique was used to select 200 chili farms from the Volta region. The first stage involved the purposive selection of the four districts based on the Millennium Development Authority's observation that the southern horticultural belt of Ghana is made up of 7 districts of the Volta region (MiDA, 2010). The second stage involved the purposive selection of the communities noted for chili pepper production and the third stage involved the random selection of chili farmers. The selected districts were South Tongu district, Ketu-South district, North Dayi district and Keta municipality. A total of 50 chili farmers were sampled from each district/municipality leading to a sample size of 200 respondents. The data was collected through personal interview whilst using a well-structured questionnaire.

Analytical framework

This study adopts the stochastic frontier production and cost function models to analyze the technical, allocative and economic efficiencies of chili farms in the Volta region of Ghana. The stochastic frontier approach is adopted because of its ability to segregate the inefficiency effect from the noise effect. The stochastic frontier approach as simultaneously proposed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) is specified as:

$$Y_i = f\left(X_i;\beta\right).\exp\left(v_i - u_i\right) \quad u_i \geq 0 \tag{1}$$

where Y_i denotes the maximum output for the i^{th} farm. $f\left(X_i;\beta\right)$ represents a suitable production function of row vector of inputs X_i for the i^{th} farm and a vector β of unknown parameters to be estimated. The stochastic frontier model specified above attributes the total variation in output to an error term which is made up of two components $\left(v_i - u_i\right)$. Where v_i is the random error which captures the effects of the conditions beyond the control of the farmer and u_i is the non-negative error term which accounts for technical inefficiency (conditions under the direct control of the farmer).

The i^{th} farm's technical efficiency (TE_i) measure is given by the ratio of the realized output (Y_i) given the values of its inputs and inefficiency effects to the corresponding maximum potential output (Y_i^*) assuming there were no inefficiencies arising from the production process. Thus the technical efficiency of the i^{th} farm is given as:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta)\cdot \exp(v_i - u_i)}{f(X_i;\beta)\cdot \exp(v_i)} = \exp(-u_i) \qquad (2)$$

Equation 2 shows that the difference between Y_i and Y_i^* is captured by u_i. And if $u_i = 0$, then $Y_i = Y_i^*$, denoting that the output lies on the frontier and thus the farm is technically efficient and obtains its maximum potential output given the level of inputs. However, if $u_i > 0$, the production lies below the frontier and the farm is technically less efficient. Following Battese and Coelli (1995), v_i is assumed to be independent of u_i and it is also assumed to be independently, identically and normally distributed with a mean of zero and a constant variance, $\sigma_v^2, [v_i \sim N(0, \sigma_v^2)]$. u_i is also assumed as a truncation of the normal distribution with mean μ_i and variance $\sigma_u^2, [u_i \sim N(\mu_i, \sigma_u^2)]$, such that the mean is defined as:

$$\mu_i = Z_i \delta \qquad (3)$$

where Z_i is a vector of inefficiency factors and δ is a vector of unknown parameters to be estimated. Based on the distributional assumptions which underpin the random error term, this study adopts the single-stage maximum likelihood estimation procedure to estimate the parameters of the stochastic frontier and the inefficiency models concurrently (Onumah et al., 2010). The farm-specific TE_i are parameterized according to Battese and Corra (1977) as:

$$\sigma^2 = \sigma_v^2 + \sigma_\mu^2 \text{ and } \gamma = \sigma_\mu^2 / \sigma^2 = \sigma_\mu^2 / (\sigma_v^2 + \sigma_\mu^2)$$

Gamma (γ) has a value which ranges between zero and one. For $0 < \gamma < 1$, then output variability is as a result of the presence of both technical inefficiency and the stochastic errors.

According to Coelli et al. (2005), when information on prices are given and firms are assumed to be operating under the assumption of cost minimization, then the cost frontier can be used to estimate the economic characteristics of the production technology and also to predict the cost efficiency of the firms. The stochastic frontier cost function for a cross-sectional data can be stated as:

$$C_i \geq g(Y_i, P_i; \varphi).\exp(v_i + u_i), \quad i = 1, 2, \ldots, N \qquad (4)$$

where C_i denotes the total cost of production of the i^{th} farm, $g(Y_i, P_i; \varphi)$ represents a suitable cost function, Y_i is a vector of output produced by the i^{th} farm, P_i denotes a vector of input prices, φ is a vector of parameters to be estimated, u_i denotes inefficiency and v_i is the random noise. The composed error term, $(v_i + u_i)$ is positive because inefficiencies arising from the production process are always assumed to increase production cost (Coelli et al., 1998). This equation shows that the production cost is greater or equal to the minimum cost of production.

According to Ogundari and Ojo (2007), the farm-specific allocative efficiency (AE_i) of the i^{th} farm is calculated by the ratio of the predicted minimum cost of production (C_i^*) to the corresponding actual total cost of production (C_i) and it is specified as:

$$AE_i = \frac{C_i^*}{C_i} = \frac{E(C_i / P_i, u_i = 0)}{E(C_i / P_i, u_i)} = \exp(u_i) \qquad (5)$$

The measure of AE_i has a value ranging from zero to one, where one indicates a fully efficient farm and zero implies a fully inefficient farm.

Empirical model specification

Although the Cobb-Douglas functional form is easy to implement, it imposes a severe constraint on the technology of the firm by restricting the production elasticities to be constant and the elasticities of input substitution to be equal to one (Wilson et al., 1998). The translog functional form also suffers from multi-collinearity problems (Dawson et al., 1991). However, Coelli (1995) observed that the translog frontier functional form is less restrictive, allowing for the combination of squared and cross product terms of the explanatory variables with the view of obtaining goodness of fit of the model. Based on the strengths and weaknesses of the two functional forms, the translog functional form is adopted for this study, after testing for the significance of the interaction terms of the model.

In this study, the translog model of the production function was modified to capture the productivity associated with the price of fertilizer (PFert), family labour (Flabour) and hired labour (Hlabour) due to the effect of zero observations. For further information on this specification, see Battese and Coelli (1995), Battese and Broca (1997), Onumah and Acquah (2011) and Villano et al. (2015). The model is stated as:

$$InY_i = \beta_0 + \alpha_1 DFL_i + \alpha_2 DHL_i + \alpha_3 DPF_i + \sum_{n=1}^{6} \beta_n InX_{ni} + 0.5 \sum_{n=1}^{6}\sum_{m=1}^{6} \beta_{nm} InX_{ni} InX_{mi} + (v_i - u_i) \qquad (6)$$

where Y_i denotes the total quantity of chili pepper produced in kilograms (kg), DFL_i is the binary variable for family labour which has a value of one if family labour is used and zero if otherwise, DHL_i is the binary variable for hired labour which has a value of one if hired labour is used and zero if otherwise and DPF_i is the dummy variable for the price of fertilizer which has the value of one if the farmer uses fertilizer and zero if otherwise. According to

Battese (1997), without the inclusion of DFL_i, DHL_i and DPF_i, the estimator for the responsiveness of chili output with respect to the use of family labour, hired labour and price of fertilizer could be biased. Flabour (X_1) represents the number of family labour used (in man-days). In Equation 6, $In(X_{1i})$ is expressed as $In[\max(Flabour_i, 1 - DFL_i)]$ which denotes zero usage of family labour. Hlabour (X_2) denotes the number of hired labour used (in man-days) and $In(X_{2i})$ in Equation 6 is expressed as $In[\max(Hlabour_i, 1 - DHL_i)]$ which represents zero usage of hired labour. PFert (X_3) denotes the price of the quantity of fertilizer used (GH¢) and $In(X_{3i})$ in Equation 6 is expressed as $In[\max(\text{PFert}, 1 - DPF_i)]$. Farm size (X_4) denotes the quantity of land (hectares) cultivated to chili pepper. Quantity of seed (X_5) is the total quantity of chili pepper seed (kg) that is used in the planting process. Othercost (X_6) comprises of the price of chemicals, price of capital inputs and price of irrigation water (GH¢) used during the cropping season under consideration. v_i and u_i have their usual meanings. This study assumes that the elasticities of chili output associated with other input factors (except family labour, hired labour and price of fertilizer) are the same for farmers who did not use family labour, hired labour or fertilizer as for those who did use these inputs.

The modified cost frontier of the translog functional form which provides the basis for estimating the AE of chili farms in the Volta region of Ghana is specified as follows:

$$lnC_i = \beta_0 + \alpha_1 DPFL_i + \alpha_2 DPHL_i + \alpha_3 DPF_i + \alpha_4 DFR_i + \sum_{n=1}^{6} \beta_n InP_{ni} + \frac{1}{2}\sum_{n=1}^{6}\sum_{m=1}^{6} \beta_{nm} InP_{ni}\, InP_{mi} + (v_i + u_i) \quad (7)$$

where C_i is the total cost of chili pepper production by the i^{th} farmer in GH¢, $DPFL_i$ is the dummy variable for the price of family labour which has a value of one if family labour is used in production and zero if otherwise, $DPHL_i$ is the dummy variable for the price of hired labour which has a value of one if hired labour is used and zero if otherwise, DPF_i is the dummy variable for the price of fertilizer which has a value of one if fertilizer is used and zero if otherwise and DFR_i is the dummy variable for the price of farm land which has a value of one if the farm land on which the chilies are cultivated is paid for and zero if otherwise. Without the inclusion of the intercept changes ($DPFL_i$, $DPHL_i$, DPF_i and DFR_i), the estimator for the responsiveness of total cost of chili production with respect to the prices of family labour, hired labour, fertilizer and farm land could be biased (Battese, 1997). PFlabour (P_1) is the price of family labour used (in GH¢). In Equation 7, $In(P_{1i})$ is expressed as $In[\max(PFlabour_i, 1 - DPFL_i)]$ which denotes zero usage of family labour. PHlabour (P_2) denotes the price of hired labour used (in GH¢) and $In(P_{2i})$ in Equation 7 is expressed as $In[max(PHlabour_i, 1 - DPHL_i)]$ which represents zero usage of hired labour. PFert (P_3) denotes the price of the quantity of fertilizer used (in GH¢) and $In(P_{3i})$ in Equation 7 is expressed as $In[max(PFert_i, 1 - DPF_i)]$ which represents zero usage of fertilizer. Rent (P_4) represents the price of farm land used (in GH¢) and $In(P_{4i})$ in equation (7) is expressed as $In[\max(Rent_i, 1 - DFR_i)]$ which represents no payment for the farm land. PSeed (P_5) is the price of the quantity of chili pepper seed (GH¢) used in the planting process. Othercost (P_6) comprises of the prices of chemicals, capital inputs and irrigation water that were used during the planting period (in GH¢). v_i and u_i have their usual meanings. This study assumes that the elasticities of total cost associated with other input price factors (except for prices of family labour, hired labour, fertilizer and farm land) are the same for farmers who did not use family labour, hired labour, fertilizer and farm rent as for those who did use or pay for these inputs.

Economic efficiency, which is the focus of this study is estimated from the multiplicative interaction of both technical and allocative efficiencies and specified as:

$$EE_i = TE_i * AE_i \quad (8)$$

where EE_i, TE_i and AE_i denote economic efficiency, technical efficiency and allocative efficiency of the i^{th} producer respectively. The various farm-specific and operational factors hypothesized to influence the technical and allocative inefficiencies of chili farms in the Volta region are defined by the model:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 \quad (9)$$

where μ_i denotes either technical or allocative inefficiency and δ are vectors of unknown parameters to be estimated. Z_1 denotes gender, which is a dummy variable (value of 1 if the chili farmer is a male and 0 if otherwise), Z_2 is the age of the farmer in years, Z_3 is the experience of the farmer in years, Z_4 is the interaction term for age and experience in years, Z_5 denotes the household size of respondents in number of persons, Z_6 is the dummy variable for access to credit (value of 1 if yes and 0 if otherwise), Z_7 is the number of years of education of the farmer, Z_8 is the dummy variable for access to off-farm income (value of 1 if yes and 0 if otherwise) and Z_9 is the dummy variable for access to chili cultivation related training (value of 1 if yes and 0 if otherwise).

Tests of hypotheses

These hypotheses were tested to ascertain the appropriateness of

Table 1. Hypotheses test for the stochastic frontier production function.

Null hypothesis	Log-likelihood value	Test statistic (λ)	Critical Value ($\lambda^2_{0.001}$)	Decision
1. H_o: $\beta_{nm} = 0$	-154.623	59.323***	38.932	Reject H_o
2. H_o: $\gamma = \delta_o = \delta_1 = \delta_2 =, \ldots, = \delta_7 = 0$	-	18.074[a]	16.670	Reject H_o
3. H_o: $\gamma = 0$	-	2.852[a]	2.706	Reject H_o
4. H_o: $\alpha_1 = \alpha_2 = \alpha_3 = 0$	-162.664	16.083***	12.838	Reject H_o

[a]Obtained from Table 1 of Kodde & Palm (1986, p. 1246), *** corresponds to 1% significance level.

Table 2. Hypotheses test for the stochastic frontier cost function.

Null hypothesis	Log-likelihood value	Test statistic (λ)	Critical value ($\lambda^2_{0.001}$)	Decision
1. H_o: $\beta_{nm} = 0$	10.493	386.425***	50.993	Reject H_o
2. H_o: $\gamma = \delta_o = \delta_1 = \delta_2 =, \ldots, = \delta_7 = 0$	-	37.001[b]	22.956	Reject H_o
3. H_o: $\gamma = 0$	-	23.751[b]	9.500	Reject H_o
4. H_o: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$	230.047	160.892***	14.860	Reject H_o

[b]Obtained from Table 1 of Kodde and Palm (1986, p. 1246), ***Corresponds to 1% significance level.

the specified frontier function and the presence of inefficiency effects and the relevance of farm-specific and socio-economic factors in explaining the inefficiency of the chili farms. The tested hypotheses are: (1) $H_0: \beta_{nm} = 0$, the null hypothesis that the coefficients of the second-order variables in the translog models are zero; (2) $H_0: \gamma = \delta_0 = \delta_1 = \delta_2 =, \ldots, = \delta_9 = 0$, the null hypothesis that inefficiency effects are absent from the models at all levels; (3) $H_0: \gamma = 0$, the null hypothesis that the inefficiency effects are non-stochastic and (4) $H_0: \alpha_1 = \alpha_2 = \alpha_3 = 0$, the null hypothesis that there are no intercept changes.

These hypotheses were validated using the generalized likelihood-ratio statistic, λ, which is specified as:

$$\lambda = -2[\text{In}\{L(H_0)\} - \text{In}\{L(H_1)\}] \quad (10)$$

where $L(H_0)$ and $L(H_1)$ denote the values of the likelihood function under the specification of the null (H_0) and alternative (H_1) hypotheses, respectively. λ has a Chi-square distribution if the given null hypothesis is true with a degree of freedom equal to the number of restrictions in the model under the null hypothesis. Coelli (1995) proposed that all critical values can be obtained from the appropriate Chi-square distribution. However, if the null hypothesis involves $\gamma = 0$, then λ has a mixed chi-square distribution and hence the critical values for λ should be read from Table 1 of Kodde and Palm (1986).

RESULTS AND DISCUSSION

Tests of hypotheses

As shown in Tables 1 and 2, the first hypotheses evince that the translog rather than the Cobb-Douglas functional form is a valid representation of the data. This is shown by the rejection of the first hypotheses in both the stochastic frontier production and cost functions. The second hypotheses which specify that inefficiency effects are absent from both models at all levels are also rejected, implying that technical and allocative inefficiency effects are present in both models. The third hypotheses that the inefficiency effects are non-stochastic are also rejected implying that the traditional average response (OLS) function is not an adequate representation of the data. The fourth hypotheses that there are no intercept changes are also rejected in favour of the alternate, implying that the estimates of the parameters of the stochastic frontier production and cost functions would have been biased if these dummies to account for intercept effects in dealing with zero observations in some of the input variables had not been introduced.

Results of the stochastic frontier production function

The maximum likelihood estimates of the stochastic frontier production function are shown in Table 3. The results show that the estimated intercept coefficients for hired and family labour are negative and significant while that of price of fertilizer is positive but has a weak relationship. The estimates of the parameters of the stochastic frontier production function would have been biased if the combined effect of these dummies to account for zero observations in hired labour, family labour and the price of fertilizer were not incorporated in the model. This is further validated by the rejection of the fourth hypothesis in Table 1 (that is, there is no intercept change) in the test of hypotheses. The gamma value is 0.7323 and it is statistically significant at 1%, implying that about 73% of the total deviations from the efficient chili frontier output is due to inefficiencies arising from the production process while the random effects constitute about 27%. This further means that technical inefficiency effects dominate the noise effect in explaining the total variation in chili output. The findings also show that chili pepper output responded positively to all the input variables except family labour. This implies that a percentage increase in farm size, hired labour, price of fertilizer, quantity of seed and othercost will result in 0.34, 0.28, 0.21, 0.09, and 0.18% increase in chili output, respectively. However, a percentage increase in family labour may decrease chili output by 0.29%. This may be attributed to the excessive use of family labour for chili pepper cultivation which leads to diminishing returns. Since majority of the farmers are resource poor and are unable to pay for the services of hired labour, they tend to depend heavily on the services of their family members for production activities, resulting in the excessive use of family labour. The estimated elasticities for farm size, family labour, hired labour and price of fertilizer are statistically significant at 1%, whiles that of other cost is at 10%. The estimated return to scale is 0.82, implying that on average, chili farms in the Volta region of Ghana are characterized by decreasing returns to scale. This means that a proportionate increase in all the inputs will result in a less than proportionate increase in chili output. The realized return to scale is higher than the 0.304 obtained by Wosor and Nimoh (2012) in their study of the resource use efficiency of chili farms in the Keta municipality of the Volta region.

Results of the stochastic frontier cost function

The maximum likelihood estimates of the stochastic frontier cost function for the allocative efficiency are presented in Table 4. The predicted elasticities for all the input price variables are positive and significant at 1%. This means that all the input prices contributed significantly and directly to the total cost of chili pepper production. This implies that a percentage increase in the price of farm land, price of hired labour, price of family labour, price of fertilizer, price of seed and other costs will increase the total cost of chili pepper production by 0.0398, 0.3999, 0.4087, 0.0791, 0.0370 and 0.0599%, respectively. Output however has a weak positive relationship with the total cost of chili production. This positive relationship might mean that a 1% increase in chili output will lead to a 0.0047% increase in the total cost of chili production. The findings also show that the estimated intercept coefficients for the price of farm land, price of fertilizer, prices of hired and family labours are significantly positive. These estimated parameters show that the estimates of the parameters of the cost frontier function would have been biased if these dummies to account for intercept effect in dealing with zero observations in the price of farm land, price of fertilizer, price of hired labour and price of family labour were not included in the model. This is further confirmed by the rejection of the fourth null hypothesis in Table 2 (that is, there is no intercept change) in the test of hypotheses. The estimated gamma (γ) value of the allocative efficiency model is 0.9853 and it is significant at 1%, implying that the inability of the chili farmers to operate at the minimum cost frontier is largely due to conditions under their direct control while conditions beyond their control constitute about 1.47% of that inability.

Distribution of technical, allocative and economic efficiency scores

The frequency distribution of the various estimates of technical, allocative and economic efficiencies of chili farms in the Volta region of Ghana are presented in Figure 1.

Technical, allocative and economic efficiency scores varied greatly among the sampled chili farms. The predicted technical, allocative and economic efficiencies ranged from 18.62 to 92.06%, 69.76 to 99.58% and 17.40 to 91.10%, respectively with their means being 70.97, 92.65 and 65.76%, respectively. This mean TE estimate shows that on average, chili farms are operating at 29.03% below the efficient frontier output. This therefore implies that with the current level of technology and resource endowment, chili farms in the Volta region can increase chili output by 29.03% through the adoption of the best farm practices. The mean AE estimate of 92.65% implies that on average chili farms are operating at 7.35% above the minimum attainable cost frontier. Consequently, there is the possibility for the chili farmers to minimize cost by an average of 7.35% through the adoption of the practices of the best cost efficient farm. These high allocative efficiency estimates of the sampled chili farms confirm the hypothesis formulated by Schultz (1964) that resource-poor farmers in developing countries are highly efficient in allocating the scarce financial resources at their disposal. The mean EE of 65.76% shows that on average, the ability of the chili farmers to produce a

Table 3. Maximum likelihood estimates of the stochastic frontier production function.

Variable	Parameters	Coefficients	Standard error
Constant	β_0	4.5768***	1.1274
LnFarmsize	β_1	0.3437***	0.1426
LnHLabour	β_2	0.2845***	0.0803
LnFLabour	β_3	-0.2880***	0.0846
LnCFert	β_4	0.2065***	0.0776
LnQntySeed	β_5	0.0938	0.1103
LnOthercost	β_6	0.1795*	0.1102
Dummy for Hlabour	α_1	-2.2433***	0.7674
Dummy for Flabour	α_2	-1.9802**	0.8877
Dummy for CFert	α_3	0.1757	0.8736
0.5Ln(Farmsize)^2	β_7	0.3975**	0.2202
0.5Ln(HLabour)^2	β_8	0.0657*	0.0481
0.5Ln(FLabour)^2	β_9	-0.2736***	0.0958
0.5Ln(CFert)^2	β_{10}	0.0461	0.0721
0.5Ln(QntySeed)^2	β_{11}	0.0722	0.1042
0.5Ln(Othercost)^2	β_{12}	-0.3602*	0.2188
LnQntySeed*LnFLabour	β_{13}	-0.0072	0.0447
LnCFert*LnFLabour	β_{14}	-0.0381	0.0341
LnCFert*LnQntySeed	β_{15}	-0.0475	0.0424
LnOthercost*LnFLabour	β_{16}	0.0336	0.1118
LnOthercost*LnQntySeed	β_{17}	0.0307	0.0835
LnOthercost*LnCFert	β_{18}	-0.0163	0.0532
LnHLabour*LnFLabour	β_{19}	-0.0533	0.0678
LnHLabour*LnQntySeed	β_{20}	0.1390***	0.0568
LnHLabour*LnCFert	β_{21}	-0.0097	0.0201
LnHLabour*LnOthercost	β_{22}	0.1154*	0.0749
LnFarmsize*LnFLabour	β_{23}	-0.0100	0.0842
LnFarmsize*LnQntySeed	β_{24}	-0.1033	0.0964
LnFarmsize*LnCFert	β_{25}	0.0812	0.0715
LnFarmsize*LnOthercost	β_{26}	0.0277	0.2318
LnFarmsize*LnHLabour	β_{27}	-0.2893***	0.0939
Sigma squared	σ^2	0.6429***	0.2163
Gamma	γ	0.7323***	0.1245
Log-likelihood	-	-154.6230	-

*, **, ***Statistically significant at levels of 0.1, 0.05, and 0.01, respectively.

Table 4. Maximum likelihood estimates of the stochastic frontier cost function.

Variable	Parameter	Coefficients	Standard error
Constant	β_0	-5.4968***	0.3815
LnFarmRent	β_1	0.0398***	0.0069
LnCHLabour	β_2	0.3999***	0.0087
LnCFLabour	β_3	0.4087***	0.0071
LnOthercost	β_4	0.0599***	0.0109
LnCFert	β_5	0.0791***	0.0079
LnCSeed	β_6	0.0370***	0.0107
LnOutput	β_7	0.0047	0.0095
Dummy for FarmRent	σ_1	0.0171	0.0471
Dummy for CHLabour	σ_2	2.7098***	0.2858
Dummy for CFLabour	σ_3	2.5757***	0.1882
Dummy for CFert	σ_4	0.1717**	0.1003
0.5Ln(FarmRent)^2	β_8	0.0144***	0.0060
0.5Ln(CHLabour)^2	β_9	0.1823***	0.0088
0.5Ln(CFLabour)^2	β_{10}	0.1654***	0.0077
0.5Ln(Othercost)^2	β_{11}	0.0968***	0.0172
0.5Ln(CFert)^2	β_{12}	0.0387***	0.0080
0.5Ln(CSeed)^2	β_{13}	0.0002	0.0114
0.5Ln(Output)^2	β_{14}	-0.0052	0.0136
LnCSeed*LnOutput	β_{15}	-0.0119*	0.0089
LnCFert*LnOutput	β_{16}	-0.0002	0.0046
LnCFert*LnCSeed	β_{17}	0.0053	0.0044
LnOthercost*LnOutput	β_{18}	0.0191*	0.0145
LnOthercost*LnCSeed	β_{19}	0.0050	0.0120
LnOthercost*LnCFert	β_{20}	-0.0137***	0.0050
LnCFLabour*LnOutput	β_{21}	0.0174***	0.0060
LnCFLabour*LnCSeed	β_{22}	0.0174***	0.0044
LnCFLabour*LnCFert	β_{23}	-0.0125***	0.0025
LnCFLabour*LnOthercost	β_{24}	-0.0167***	0.0072
LnCHLabour*LnOutput	β_{25}	-0.0142*	0.0090
LnCHLabour*LnCSeed	β_{26}	0.0153**	0.0087
LnCHLabour*LnCFert	β_{27}	0.0018	0.0030
LnCHLabour*LnOthercost	β_{28}	-0.8190***	0.0114
LnCHLabour*LnCFLabour	β_{29}	-0.1186***	0.0052
LnFarmRent*LnOutput	β_{30}	-0.0109**	0.0058
LnFarmRent*LnCSeed	β_{31}	-0.0079*	0.0055
LnFarmRent*LnCFert	β_{32}	0.0009	0.0019

Table 4. Cont'd

LnFarmRent*LnOthercost	β_{33}	0.0023	0.0069
LnFarmRent*LnCFLabour	β_{34}	0.0106***	0.0027
LnFarmRent*LnCHLabour	β_{35}	-0.0089**	0.0044
Sigma-squared	σ^2	0.0066***	0.0007
Gamma	γ	0.9853***	0.0444
Log-likelihood	-	310.4927	

*, **, ***Statistically significant at levels of 0.1, 0.05, and 0.01 respectively.

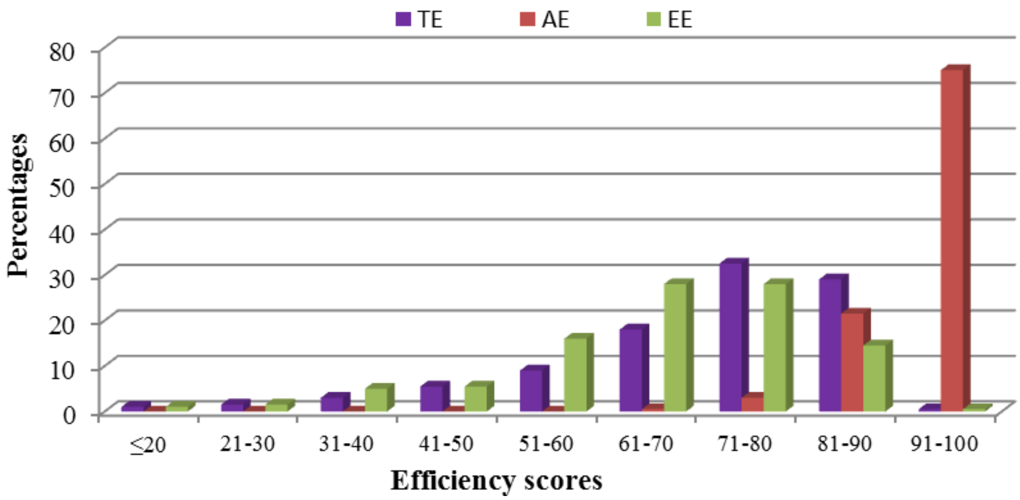

Figure 1. Distribution of efficiency scores (Author's Computation from Field Survey, 2013).

predetermined level of output at the lowest attainable cost is relatively low. The findings further show that substantial gains in EE can be achieved by improving the technical and allocative efficiencies of the chili farmers.

Following the work of Bravo-Ureta and Pinheiro (1997), the efficiency scores also indicate that if the average chili farmer is to attain the efficiency level of the most technically efficient chili farm among the sampled chili farms, that farmer will have to realize a 22.91% cost savings (that is, 1- [70.97/92.06]). Also, the most technically inefficient chili farmer will have to realize a cost reduction of 79.77% (that is, 1- [18.62/92.06]) in order to achieve the technical efficiency level of the most efficient chili farm. From the allocative efficiency scores, the average and least efficient chili farms will have to realize cost reductions of 6.96% (that is, 1- [92.65/99.58]) and 29.95% (that is, 1- [69.76/99.58]), respectively before they can attain the efficiency level of the most allocative efficient chili farm among the sampled chili farms. The results further show that the average and the most economically inefficient chili farms must save cost by 27.82% (that is, 1- [65.76/91.10]) and 80.90% (that is, 1- [17.40/91.10]), respectively to be able to attain the efficiency status of the most economic efficient chili farm among the sampled chili farms. It is evident from these findings that substantial gains in EE can be achieved and that technical inefficiency effects pose more challenge to EE than allocative inefficiency effects.

Determinants of technical and allocative inefficiency

The results of the analysis of the technical and allocative inefficiency models are shown in Table 5. Since EE is composed of technical and allocative efficiencies, economic inefficiency also arises from the joint effects of technical and allocative inefficiencies (Bravo-Ureta and Pinheiro, 1993). Knowledge of these inefficiency factors according to Bravo-Ureta and Pinheiro (1993) is of great importance in formulating appropriate policies towards the attainment of the frontier output given the technology level. The results of the inefficiency models revealed female chili farmers to be technically more efficient than their male counterparts. Male farmers however are allocatively more efficient than their female counterparts. This finding is not surprising since much of the labour that

Table 5. Technical and allocative inefficiency models.

Variable	Parameter	Coefficients	
		TE	AE
Constant	δ_0	-3.475 (2.478)*	0.085 (0.077)
Gender	δ_1	0.602 (0.448)*	-0.051 (0.026)**
Age	δ_2	0.043 (0.029)*	-0.002 (0.001)
Experience	δ_3	0.263 (0.155)**	0.012 (0.005)**
Age*Experience	δ_4	-0.006 (0.003)**	-0.002 (0.001)**
Household size	δ_5	0.085 (0.046)**	0.001 (0.003)
Credit	δ_6	0.600 (0.356)**	0.043 (0.020)**
Education	δ_7	-0.036 (0.033)	-0.006 (0.003)**
Off-farm income	δ_8	-0.213 (0.219)	-0.038 (0.021)**
Training	δ_9	0.325 (0.516)	0.070 (0.032)**

Values in parenthesis are standard errors; *, **Statistically significant at levels of 0.1 and 0.05, respectively.

is required for farm operations (weeding, transplanting, harvesting, processing, etc) are supplied by women. Since chili plants are very delicate, they require care and patience in handling them and this is done better by females than males. On the other hand, male farmers who may mostly be the heads of their respective households may want to minimize cost in order to save money for the upkeep of their farm families and by so doing may end up producing at the minimum attainable cost. This finding contradicts the views of Onumah et al. (2013) who found male cocoa growers to be technically more efficient than their female counterparts. It is however in consonance with Amewu and Onumah (2015) who found male NERICA rice farmers to be allocatively more efficient than their female counterparts. The age of chili farmers has a positive relationship with technical inefficiency, implying that aged farmers are less efficient relative to their youngsters. This result agrees with the findings of Asante et al. (2014), Mariano et al. (2011) and Khan and Saeed (2011). The implication of this finding is that policies that are aimed at persuading the teaming youth to go into chili pepper cultivation should be implemented since it has the potential to boost chili production. Surprisingly, experienced chili farmers are found to be technically and allocatively less efficient than their inexperienced counterparts. This may be attributed to the fact that most experienced farmers may tend to rely solely on their knowledge and so may not seek advisory services from extension officers and this may lead to their inefficiency compared to their inexperienced counterparts who may be willing to seek extension advice. This finding concurs with the findings of Onumah and Acquah (2011) and Onumah et al. (2010) who posit that new farmers are progressive and willing to implement new farming systems, leading to high level of efficiency as opposed to their experienced counterparts. Even though the individual effects of age and experience of the farmers are found to influence technical and allocative inefficiency positively, this study illustrates that the joint effect of these factors impact technical and allocative inefficiency negatively. This implies that aged farmers with numerous years of experience in chili pepper cultivation are relatively more efficient as opposed to aged farmers who are less experienced or experienced young farmers. This finding reveals that people who go into chili farming at old age (e.g. after retirement) are less efficient as opposed to those who enter at tender age since they tend to acquire more experience as they grow. Onumah and Acquah (2011) also realized a similar relationship in their study of the technical efficiency and its determinants of Ghanaian fish farms. Contrary to expectations, farm families with relatively larger household sizes are found to be relatively less efficient than those with relatively smaller sizes. This finding is confirmed by the negative contribution of family labour to chili output. A summary statistic of the data revealed that more than 92% of the sampled chili farms are less than 2 hectares and increasing labour inputs on these atomized land holdings will lead to diminishing returns. This finding lends support to Effiong (2005) and Idiong (2006) who argued that larger household sizes do not necessarily ensure increased efficiency since family labour is made up of children who are always in school. Contrary to the findings of Onumah et al. (2013), Khan and Saeed (2011) and Mbanasor and Kalu (2008), but consistent with the findings of Okike et al. (2001), chili farmers who had access to credit facilities operate with less technical and allocative efficiency than those without access. This may be ascribed to the fact that majority of the farmers who had access to credit facilities may not have used the credits for the planned purposes. Since most of the chili farmers are resource poor and have large family sizes, a high possibility of credit diversion into meeting their daily needs may exist among them. Consistent with the results of Bravo-Ureta and Pinheiro (1997), Khan and Saeed (2011), and Abdulai and Huffman (2000), chili farmers with more years of education are found to be allocatively more efficient than their counterparts who are less educated. According to Khan and Saeed (2011), education helps to sharpen the managerial skills of farmers thereby enabling them to be good decision makers with regards to input usage. Chili farmers who engage in other forms of income generating activities are found to be allocatively more efficient than their counterparts who do not engage in such activities. Engagement in off-farm activities yield returns which increase the purchasing power of the farmers, enabling them to purchase productivity enhancing inputs for chili cultivation. This result contradicts the views of Abdulai and Eberlin (2001), Nkegbe (2012) and Mariano et al. (2011). Contrary to expectations, chili farmers who had access to some form of training in chili cultivation operate with less allocative efficiency than those who do not have access to such forms of training. This can be attributed to the infrequent nature of the training since majority of those who were trained could not remember the last time they received such forms of training. This result contradicts the views of Galawat and Yabe (2012) and Rahman et al. (2015) who found participation in rice training programs to have increased the efficiency of rice producers in Brunei Darussalam and Bangladesh, respectively.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Based on the findings of the study, the following conclusions are drawn. Chili pepper output in the study area is greatly influenced by farm size, hired labour, family labour, price of fertilizer and othercost of production. The production technology of chili farms is characterized by decreasing returns to scale. The total cost of chili pepper cultivation in the study area is significantly influenced by the price of farm land, price of hired labour, price of family labour, price of fertilizer, price of seed and othercosts. However, output does not significantly influence total cost though they are positively related.

Chili farms in the study area are economically less efficient and this is largely due to the presence of both technical and allocative inefficiencies in chili production with technical inefficiency effects constituting a more serious problem to economic efficiency than allocative inefficiency effects. This implies that economic efficiency could be improved substantially by improving both technical and allocative efficiencies, however improvement in technical efficiency offers a higher potential for enhancing economic efficiency than in allocative efficiency. This further implies that chili farmers in the study area generally make good decisions with respect to input allocation rather than good decisions regarding the perfect conversion of inputs into output.

The results also demonstrate the import of examining not only technical efficiency as a measure of productivity but also allocative and economic efficiency components. The current economic efficiency level of the farmers implies that the ability of the chili farmers to produce a potential level of output at a lower cost is relatively low on average and needs to be improved. There is the presence of both technical and allocative inefficiencies among the chili pepper producers in the study area and these inefficiencies are greatly influenced by farmers' socio-economic characteristics as well as technical and institutional factors. The joint effects of technical and allocative inefficiencies are responsible for explaining the level of variations in the economic efficiency of chili farms although the individual effects of some variables are statistically non-significant.

On the basis of the findings, the study recommends that chili farmers should rely more on the services of hired labour rather than family labour and those who desire to make efficient use of the services of their large farm families should increase their farm-sizes so as to commensurate the quantity of available family labour. The study also recommends policies that aim at attracting the teaming youth into chili pepper cultivation to be pursued by the government and other stakeholders of the chili industry. These policies should focus on giving incentive packages such as enhancing the access of the youth to improved inputs at subsidized prices, especially young female chili farmers since female farmers are found to be technically more efficient than their male counterparts. The study further recommends that experienced chili farmers should not rely solely on their know-how but should endeavour to complement their knowledge with advisory services. Furthermore, financial institutions and other credit providers should focus on providing credit to the farmers in the form of inputs rather than cash and these inputs should directly be channeled into production activities so as to avert the possible diversion of these inputs.

Conflict of Interests

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

Funding support for this study was provided by the International Food Policy Research Institute (IFPRI), Ghana under the Ghana Strategy Support Program (GSSP) and the authors wish to thank them.

REFERENCES

Abdulai A, Eberlin R (2001). Technical efficiency during economic reform in Nicaragua: Evidence from farm household survey data. Econ. Syst. 25(2):113–125.

Abdulai A, Huffman W (2000). Structural adjustment and economic efficiency of rice farmers in Northern Ghana. Econ. Dev. Cult. Change 48(3):503-20.

Aigner DJ, Lovell CAK, Schmidt PJ (1977). Formulation and estimation of stochastic frontier production function models. J. Econ. 6:21-37.

Amewu S, Onumah EE (2015). Cost efficiency of NERICA producing households in Ghana: a modified non-neutral stochastic frontier analysis. Am. J. Exp. Agric. 9(6):1-13.

Asante BO, Villano RA, Battese GE (2014). The effect of the adoption of yam minisett technology on the technical efficiency of yam farmers in the forest-savanna transition zone of Ghana. Afr. J. Agric. Resour. Econ. 9(2):75-90.

AVRDC (Asian Vegetable Research Development Centre) (2006). Vegetables Matter. AVRDC – The World Vegetable Center. Shanhua, Taiwan.

Battese GE (1997). A note on the estimation of Cobb-Douglas production functions when some explanatory variables have zero values. J. Agric. Econ. 48:250-252.

Battese GE, Broca SS (1997). Functional forms of stochastic frontier production functions and models for technical inefficiency effects: a comparative study for wheat farmers in Pakistan. J. Prod. Anal. 8:395-414.

Battese GE, Coelli TJ (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. Empir. Econ. 20:325-332.

Battese GE, Corra GS (1977). Estimation of a production frontier model: with application to the pastoral zone of Eastern Australia. Aust. J. Agric. Econ. 21:169-179.

Bravo-Ureta BE, Pinheiro AE (1993). Efficiency analysis of developing country agriculture: a review of the frontier function literature. Agric. Resour. Econ. Rev. 22(1):88-101.

Bravo-Ureta BE, Pinheiro AE (1997). Technical, economic, and allocative efficiency in peasant farming: Evidence from the Dominican Republic. Dev. Econ. 35(1):48-67.

Coelli TJ (1995). Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. J. Prod. Anal. 6:247-268.

Coelli TJ, Rao DSP, Battese GE (1998). An Introduction to Efficiency and Productivity analysis. Kluwer Academic Publishers. Boston. USA.

Coelli TJ, Rao DSP, O'Donnell CJ, Battese GE (2005). An introduction to efficiency and productivity analysis, 2nd edition. Springer Publishers, New York, New York, USA.

Dawson PJ, Lingard J, Woodford CH (1991). A generalized measure of farm-specific technical efficiency. Am. J. Agric. Econ. 73(4):1099-1104.

Effiong EO (2005). Efficiency of Production in Selected Livestock Enterprises in Akwa Ibom State, Nigeria. Ph.D Dissertation. Dept. of Agricultural Economic, Michael Okpara University of Agriculture, Umudike. Nigeria.

Galawat F, Yabe M (2012). Profit efficiency in rice production in Brunei Darussalam: A stochastic frontier approach. J. Int. Soc. Southeast Asian Agric. Sci. 18(1): 100–112

Ghana Statistical Service (GSS) (2014). Ghana Living Standards Survey Report of the Sixth Round (GLSS 6), Accra, Ghana.

Idiong IC (2006). Evaluation of Technical, Allocative and Economic Efficiencies in Rice Production System in Cross River State, Nigeria. Ph.D Thesis, Michael Okpara University of Agriculture, Umudike, Nigeria.

Khan H, Saeed I (2011). Measurement of Technical, Allocative and Economic Efficiency of Tomato Farms in Northern Pakistan. International Conference on Management, Economics and Social Sciences (ICMESS' 2011) Bangkok Dec., 2011.

Kodde DA, Palm FC (1986). Wald criteria for jointly testing equality and inequality restrictions. Econometrica . 54:1243-1248.

Mariano MJ, Villano R, Fleming E (2011). Technical Efficiency of Rice Farms in Different Agroclimatic Zones in the Philippines: An Application of a Stochastic Metafrontier Model. Asian Econ. J. 25(3):245-269.

Mbanasor JA, Kalu KC (2008). Economic efficiency of commercial vegetable production system in Akwa Ibom State, Nigeria: A translog stochastic frontier cost function approach. Trop. Subtrop. Agroecosyst. 8(3):313-318.

Meeusen W, Van den Broeck J (1977). Efficiency Estimation from Cobb-Douglas Production Functions with composed Error. Int. Econ. Rev.18:435-444.

MiDA (Millennium Development Authority) (2010). Investment opportunity in Ghana chili pepper production. A publication of MiDA in conjunction with the United States Millennium Challenge Corporation.

MoFA (Ministry of Food and Agriculture) (2014). Agriculture in Ghana: Facts and Figures (2013). Annual Report compiled by the Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture as part of MoFA's Policy Planning Monitoring and Evaluation activities. Accra, Ghana.

Nkegbe PK (2012). Technical efficiency in crop production and environmental resource management practices in northern Ghana. Environ. Econ. 3(4):43–51.

Ogundari K, Ojo SO (2007). Economic Efficiency of Small Scale Food Crop Production in Nigeria: A Stochastic Frontier Approach. J. Soc. Sci. 14(2):123-130.

Okike I, Jabbor MA, Smith KV, Akinwumi JW, Ehui SK (2001). Agricultural Intensification and Efficiency in West Africa Savannahs: Evidence from Northern Nigeria. Socio-economic and Policy Research Working Paper 33. ILRI, Nairobi.

Onumah EE, Acquah HD (2011). A stochastic production investigation of fish farms in Ghana. Agris on-line Papers in Economics and Informatics 3(2):55.

Onumah EE, Bruemmer B, Hoerstgen-Schwark G (2010). Productivity of hired and family labour and determinants of technical inefficiency in Ghana's fish farms. Agric. Econ. 56(2):79-88.

Onumah JA, Onumah EE, Al-Hassan RM, Bruemmer B (2013). Meta-frontier analysis of organic and conventional cocoa production in Ghana. Agric. Econ. 6(59):271-280.

Rahman MC, Hussain CNB, Hossain MR, Rahaman MS, Chowdhury A (2015). Comparative Profitability and Efficiency Analysis of Rice Farming in the Coastal Area of Bangladesh: The Impacts of Controlling Saline Water Intrusion. IOSR J. Agric. Vet. Sci. 8(10):89–97.

Schultz TW (1964). Transforming Traditional Agriculture. Stochastic Frontiers: A Monte-Carlo Analysis. Discussion Paper in Economics, Exeter University. New Haven: Yale University Press.

Villano R, Bravo-Ureta B, Solís D, Fleming E (2015). Modern Rice Technologies and Productivity in the Philippines: Disentangling Technology from Managerial Gaps. J. Agric. Econ. 66(1):129–154.

Wilson P, Hadley D, Ramsden S, Kaltsas L (1998). Measuring and Explaining Technical Efficiency in UK Potato Production. J. Agric. Econ. 48(3):294-305.

Wosor DK, Nimo F (2012). Resource use efficiency in Chili Pepper production in the Keta municipality of Volta Region of Ghana. Elixir Prod. Manage. 47(2012):8595-8598.