ECONOMIC EFFICIENCY OF SOYBEANS PRODUCTION IN THE NORTHERN REGION OF GHANA

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ABSTRACT

Soybean is an important cash crop with the potential of reducing poverty in the Northern Region of Ghana. Knowledge on the level of economic efficiency and the factors that influence such efficiency is a good beginning for addressing its sustainability problems. The study aimed at analysing economic efficiency of soybean production in the Northern Region of Ghana. Cross-sectional data was collected from 500 soybean farmers across five districts in the region during the 2015 cropping season. The analysis was done using translog stochastic production and cost frontier models in which technical and economic inefficiency effects were specified to be a function of farm and farm-specific factors and estimated in a one-step procedure using maximum likelihood method. Results show that soybean production in the region is characterized by increasing returns to scale. Furthermore, soybean farmers in the region are 82.7% technically efficient, 49.5% economically efficient and 59.5% allocatively efficient. These results show great scope for improving efficiencies and sustainability of soybean production in the Northern Region. The study also showed that being a relatively young farmer, access to extension services and adoption of improved seed variety reduce technical and economic inefficiency among farmers. Increase in years of schooling was found to only significantly increase technical efficiency. Reduced cost of travel from farmers' residence to their homes and practicing of monocropping significantly increased economic efficiency. Inadequate capital was found to be the most pressing constraint, as most of the farmers did not have access to credit during that cropping season. For a more efficient and sustainable production of soybean, policies that would improve access to improved soybean varieties, credit, smart subsidies and extension services, among others, should be pursued.

Keywords: Technical efficiency; Allocative efficiency; Economic efficiency; Stochastic function model, Soybean; Northern Ghana

INTRODUCTION

Ghana stands the chance of being a triple beneficiary of soybean which contains 18 to 20 % of edible oil, 45% of high quality protein and high level of essential amino acids. The crop is also used for industrial productions, including oils, soap, cosmetics, resins, plastics, inks, crayons, solvents, and clothing (Olayiwola, 2008). These three components of the crop show the economic worth of soybean seed and the potential to make significant contribution to preventive healthcare delivery of Ghana. The crop also presents to farmers alternative source of cash income to improve their livelihoods.

The Statistics, Research and Information Directorate (SRID) of MoFA (2012), reports that majority (77%) of soybean production in Ghana comes from the Northern Region and the region accounts for 40 percent of agricultural land in Ghana. As a result, several interventions have been instituted in the Northern Region including the most recent intervention from Bill and Melinda Foundation which has released twenty million US dollars for the implementation of a five-year project to boost soybeans, cowpea and groundnut cultivation in the three northern regions of Ghana. In the Northern Region, the Urban Agriculture Network (URBANET) is spearheading the project under the auspices of International Institute for Tropical Agriculture (IITA) and has already set up 20 soybeans, 15 cowpeas and 15 groundnuts demonstration fields in the region (Citifmonline, 2015). Other interventions include the Agricultural Value Chain Mentorship Project (AVCMP) which was awarded through the Alliance for a Green Revolution in Africa (AGRA) with funding from Danish International Development Agency (DANIDA). The project made available a lot of improved technologies and farming practices to the farmers. The project did not only hinge on mentoring sessions on group animations and building capacity of farmers on entrepreneurship, it also linked farmers to inputs and services, airing of radio programs, video shows, on-stage drama, distribution of print materials and establishment of on-farm demonstrations (Martey, Dogbe, Etwire, & Wiredu, 2015).

In addition to the above, Agricultural research organizations such as Savanna Agricultural Research Institute (SARI) under the Ghana's Council for Scientific and Industrial Research (CSIR) have done a lot in the generation and dissemination of soybean production technologies including improved varieties, crop management and protection techniques. These technologies include good land preparation practices, use of certified seed, dibbling, Integrated Soil Fertility Management (ISFM), Integrated Pest Management (IPM), timely execution of farm operations, soybean-rice rotation among others (Martey, Dogbe, Etwire, & Wiredu, 2015). These interventions seem to have chalked some successes in that, soybean production increased from 110,264 MT in 2009 to 144,926 MT in 2010 representing a percentage increase of about 31.44% (SRID, 2011).

Notwithstanding the above, the performance of soybean in the country is poor compared to that of countries like South Africa, Nigeria, and Uganda in Africa and United State of America (USA), Argentina, China and India. Soybean yield in Ghana averaged 1.5 Mt/Ha which is far below the achievable yield (2.3 Mt/Ha). Meanwhile, worldwide soybean yield in metric tons per hectare saw an increase during the 2014/2015 production season from 2.70 to 3.50 with USA achieving a yield of 3.20 Mt/ha, Brazil – 3.03 Mt/ha, Argentina – 3.17 Mt/ha (USDA, 2016). USA soybean yield for the 2014/2015 production season more than doubled that of Ghana, a situation which requires research into the levels as well as the determinants of economic efficiency of soybean production in the country. These are the prerequisites of any policy formulation for a sustainable production of soybean in Northern Region, and Ghana as a whole.

Hence, rather than just evaluating the technical potential of the crop, it is imperative to take a serious look at the economic considerations in terms of farmers' ability to acquire and effectively use these technologies and at the same time the chance they stand in improving their livelihoods through soybean production. Farmers' socio-economic and institutional factors often influence their choice and use of technologies and hence would make decisions within their technical and economic capacities. Selection of the most cost-effective input combination can easily be realized via economic efficiency and this can help in determining the magnitude of gains thereof by improving efficiency of the existing production technologies. This would help make savings of scarce resources to distribute to other productive sectors of the economy and thus, contribute to poverty alleviation among farmers.

Ghana's economy can benefit greatly by determining the extent to which it is possible to raise productivity or increase efficiency, at the existing resource base or technology. Each type of inefficiency (technical or economic) is costly to a firm (e.g., a farm household) in the sense that it causes a reduction in profit below the maximum value attainable under full efficiency.

This study therefore attempts to address the factors that influence the economic efficiency (technical and allocative) in the production of soybeans among smallholder farmers in the Northern Region of Ghana. In a developing agricultural economy like Ghana where resources are scarce and chances to adopt and effectively and efficiently use technologies are restricted and dwindling, it is essential to take a look at production and cost efficiency vis-as-vis the socio-economic, institutional, and location-specific factors of farmers. This would help identify potential possibilities to raise productivity at minimum cost by improving efficiency without necessarily developing and disseminating new technologies.

MATERIAL AND METHODS

Study Area and Data

The study was conducted in the Northern Region, which falls within the northern savannah ecological zone of Ghana, and where soybean production is prominent. The region occupies 70,384 square kilometres and accounts for 29.5 per cent of the total land area of Ghana with an estimated population of 2,479,461. The population is predominantly rural (69.7%) with the farming population making up to 90% and an average household size of 14, far higher than the national average probably due to the use of family labour for agricultural production. Major food crops grown in the region are cereals (maize, rice, sorghum, guinea corn and millet), root and tubers (yam, cassava and potatoes), legumes (groundnut, cowpea, soybean, pigeon pea and bambara beans) and vegetables (okro, tomatoes, pepper, onions, garden eggs, leafy melon, Shea fruits) (GSS, 2013).

The region experiences a single rainy season with a relatively dry climate. The rainy season begins in May and ends in October while the dry season starts in November and ends in March/April. Rainfall records in this part of Ghana range between 750mm and 1050mm. The dry season has maximum temperatures occurring towards the end of the season (March-April) and minimum temperatures in December and January. From December to early February, the region experiences harmattan winds which have considerable effects on temperature, causing temperature to vary widely. The day temperature ranges from 33^{o} C to 39^{o} C while mean night temperature range between 14^{0} C to 23^{0}C. The amount of water vapour in the air, humidity, is very low exacerbating the effects of heat during daytime. The relatively unfavourable climate condition though has good opportunities for some crops to thrive but it has adversely affected economic activity in the region (GSS, 2013).

On average, agriculture employs 74.9% of the population (GSS, 2013). The type of farming system practiced in the region under study is mixed farming which dominates the cropping pattern. Mono cropping activities in this area is relatively large commercial rice and maize farms. Most farming practices involve the traditional labour-intensive type characterized by the use of the hoe and cutlass.

The Eastern Corridor of the Northern Region was focused on in this study because it has a broad soybean production potential. In both production and marketing, the area is a tested example of truly agro-based area because of its strategic geographical location. Districts considered for the study included Yendi Municipal as well as Gusheigu, Nanumba North, Nanumba South and Saboba districts.

From these five districts, primary data was obtained through a cross-sectional survey of farmers during the 2015 farming season. Farm level data was collected from 500 soybean farmers in the districts using simple random sampling technique. The sample size was derived using a sample size determination formula. A conservative population proportion of 50% was expected to yield the large sample size that would be more representative. The research allowed a level of precision of 4.4% and at 95% level of confidence the sample size was computed to be 496.07, which was rounded to 500 respondents.

Analytical Approach

The stochastic frontier model was used to estimate the technical efficiency (TE), while the stochastic cost frontier function was used to analyse economic efficiency (CE). Technical efficiency is the ability of a firm to obtain maximum output from a given set of inputs. Thus, technical inefficiency occurs when a given set of inputs produces less output than what is possible given the available production technology. In estimating the TE and CE, the stochastic frontier production and cost models proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) (Coelli, O'Donnell, & Battese, 2005) were adopted.

For the Cobb-Douglas case, and in logarithmic terms, Sharma, Leung, and Zaleski (1999) had a firm technology in the form of single-output stochastic frontier specified as:

$$Y_i = f(X_i; \beta) e^{\varepsilon_i} \tag{1}$$

Equation 1, when linearized becomes

$$\ln Y_i = \beta_0 + \sum_{n=1}^{N} \beta_n \ln X_{ni} + v_i - u_i, u_i \geq 0 \tag{2}$$

Although the functional form of stochastic frontier model has been shown to have minimal impact on efficiency estimates (Kopp & Smith, 1980), the study adopted the translog function which is flexible (Coelli, O'Donnell, & Battese, 2005) and has the potential to deal with discrepancies of efficiency estimates. The translog function places far fewer restrictions before estimation, as compared to the Cobb-Douglas, or Constant Elasticity of Substitution (CES) technologies. In the case of translog, the model can be expressed as follows:

$$\ln Y_i = \beta_0 + \sum_{n=1}^{N} \beta_n \ln X_{ni} + \frac{1}{2} \sum_{n=1}^{N} \sum_{n=1}^{N} \beta_{ij} \ln X_{ni} \ln X_{nj} + v_i - u_i \ , \ u_i \geq 0 \tag{3}$$

where Y_i denotes output of the i^{th} firm, X_i is a vector actual input quantities used by the i^{th} firm; β is a vector of parameters to be estimated and $v_i - u_i \ (\varepsilon_i)$ is the composite error.

The random error v_i is assumed to be normally distributed with zero mean and constant variance (σ^2, v_i). The technical inefficiency (u_i) is independent of v_i and has half normal distribution with mean zero and constant variance (σ^2, u_i). Full technological production potential is exploited by the *i*th farm when the value of u_i comes out to be equal to zero, and the farmer is then producing at the production frontier beyond which he cannot produce. This means that the greater the magnitude of u_i from the production frontier, the higher the level of inefficiency of the farmer.

The farm-specific technical inefficiency u_i is given as:

$$U_i = \varphi_0 + \sum_{n=1}^{N} \varphi_i Z_i + \omega_i \tag{4}$$

where φ_i and ω_i respectively denote a (n x 1) vector of parameters for inputs and error term of the inefficiency model for the *i*th respondents.

The expected value of u_i is conditional on the statistical noise and measured as follows:

$$E\left[{u_i}/{\varepsilon_i}\right] = \frac{\sigma\lambda}{1+\lambda^2}\left[\frac{f_s\left({\varepsilon_i \lambda}/{\sigma}\right)}{F_i\left({-\varepsilon_i \lambda}/{\sigma}\right)} - \frac{\varepsilon_i \lambda}{\sigma}\right] \tag{5}$$

where $f_s(.)$ is the density of the standard normal distribution and $F_i(.)$ is the cumulative distribution function, (Murillo-Zamorano, 2004). To yield consistent parameters of the above equations, maximum likelihood estimation procedure was used. The variances of the random errors, σ_v^2 and those of the technical and allocative inefficiency effects, σ_u^2 and overall variance of the model σ² are related by $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

The ratio $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ measures the total variation of output from the frontier which can be attributed to technical or allocative inefficiency.

where, σ^2 = total variation, σ_u^2 = variation due to inefficiency, σ_v^2 = variation due to noise, λ= the ratio of the standard deviation of the inefficiency component to that of the noise component. The value of lambda expresses how strong the evidence of the presence of inefficiency is in the data. γ specifies the ratio of the variation due to inefficiency to the total variation. With a parametric restriction between 0 and 1, a high γ also represents the explanatory power of inefficiency in total variation (Radam, Yacob, & Muslim, 2010).

The level of technical efficiency (TE) is measured by the distance of a farm output from the production frontier. Thus, a farm that operates on the production frontier is said to be technically efficient. TE is measured as a ratio of actual to potential output (Aigner, Lovell, & Schmidt, 1977), given as:

$$TE = \frac{Y_i^*}{Y_i} = \frac{f(X_i;\beta)\exp(v_i - u_i)}{f(X_i;\beta)\exp(v_i)} = \exp(-u_i) \tag{6}$$

Taking out v_i from both sides of equation 6 gives

$$Y_i^* = Y_i - v_i = f(X_i;\beta) - u_i \tag{7}$$

where Y_i^* is the observed output of the i^{th} farm, adjusted for the stochastic noise captured by v_i. TE scores range from 0 to 1 such that if TE = 1, the farmer is efficient; otherwise the farmer is inefficient.

In estimating CE of soybean farmers, the stochastic frontier cost model was used from which the allocative efficiency values were generated. The stochastic frontier cost function was specified by altering sign of the error term in the above specification of the production function from $(v_i - u_i)$ to $(v_i + u_i)$.

Supposing that the production function again is self-dual, the dual cost frontier can be derived algebraically and written in a general form as

$$C_i = f(P_i;\beta, Y_i\ ;\beta) \tag{8}$$

where C_i is the total cost of production by the ith farmer with a corresponding output. Y_i and P_i are the vector of observed output and input prices for the i^{th} farm, and β is a vector of parameters to be estimated. The soybean farmers therefore have a translog cost frontier function specified as:

$$\ln C_i = \beta_0 + \sum_{n=1}^{N}\beta_n \ln P_{ni} + \frac{1}{2}\sum_{n=1}^{N}\sum_{n=1}^{N}\beta_{ij}\ln P_{ni}\ln P_{nj} + \beta_y \ln Y_i + \frac{1}{2}\beta_{yy}(\ln Y_i)^2 + \sum_{n=1}^{N}\beta_{iy}\ln Y_i \ln P_i + v_i + u_i \tag{9}$$

Again v_i is the symmetric error term and assumed to be identical, independent and normally distributed, $N \sim (0, \sigma_v^2)$. The second term, u_i is the inefficiency error term which is independent to the v_i and normally distributed, $N \sim (0, \sigma_u^2)$.

The farm specific economic efficiency is defined as the ratio of the minimum total production cost (C*) to the actual observed total production of cost (C) as follows;

$$EE = \frac{C_i^*}{C_i} = \frac{f(P_i;\beta, Y_i;\beta)\exp(v_i + u_i)}{f(P_i;\beta, Y_i;\beta)\exp(v_i)} = \exp(u_i) \tag{10}$$

where C* represents the production cost under ideal conditions where efficiency is achieved and C denotes the actual cost observed from the individual farmer. When $C_i^* = C_i$, it implies the absence of economic inefficiency effects in which case $u_i = 0$. Likewise, $C_i^* < C_i$ implies economic inefficiency whose scores will be less than a unity.

Following Farrel (1957), the allocative efficiency index can be determined given technical and economic efficiency scores. The economic efficiency equation, according to Kumbhakar and Lovell (2000), is given by:

$$(EE_i = TE_i \times AE_i)$$

Allocative efficiency can be expressed from the above as;

$$AE_i = \frac{EE_i}{TE_i}$$

The farm-specific economic inefficiency u_i can be modelled as:

$$U_i = \varphi_0 + \sum_{n=1}^{N} \varphi_i Z_i + \omega_i \tag{11}$$

where φ_i and ω_i respectively indicate a (n x 1) vector of parameters for inputs and error term of the inefficiency model for i^{th} respondents.

The empirical translog specification of the stochastic production frontier model is specified as

$$\ln Output = \beta_0 + \beta_1 \ln Farmsize + \beta_2 \ln Seed + \beta_3 \ln Mechanization + \beta_4 \ln Labour +$$
$$\frac{1}{2}\beta_5 (\ln Farmsize)^2 + \frac{1}{2}\beta_6 (\ln Seed)^2 + \frac{1}{2}\beta_7 (\ln Mechanisation)^2 + \frac{1}{2}\beta_8 (\ln Labour)^2 +$$
$$\beta_9 \ln Farmsize * Seed + \beta_{10} \ln Farmsize * Mechanisation + \beta_{11} \ln Farmsize * Labour +$$
$$\beta_{12} \ln Seed * Mechanisation + \beta_{13} \ln Seed * Labour + \beta_{14} \ln Mechanisation * Labour + v_i - u_i \tag{12}$$

where, $\beta_0, \beta_1, ..., \beta_{14}$ are the slope coefficients. The term $(v_i - u_i)$ is the composed error term where v_i represents randomness and captures the stochastic effects outside the farmer's control (e.g., measurement errors, weather, natural disasters, luck and other statistical noise) and u_i represents technical inefficiency of farmers. A one-step maximum likelihood estimation procedure was used.

Also, in the empirical specification of the cost function, the translog stochastic cost frontier function is assumed to be appropriate for analysing the economic efficiency of soybean production. Just as in the case of the production frontier, one-step maximum likelihood estimation procedure was used. It was done by incorporating the model for cost inefficiency effects in the translog cost function as specified below.

$$\ln C_i = \beta_0 + \sum_{n=1}^{N} \beta_n \ln P_{ni} + \frac{1}{2}\sum_{n=1}^{N}\sum_{n=1}^{N} \beta_{ij} \ln P_{ni} \ln P_{nj} + \beta_y \ln Y_i + \frac{1}{2}\beta_{yy} (\ln Y_i)^2 + \sum_{n=1}^{N} \beta_{iy} \ln Y_i \ln P_i + v_i + u_i \tag{13}$$

where, $\ln$ represents natural logarithm, C_i is the total cost in GH¢ of producing soybean by an *i*th farmer. $P_{1i}, P_{2i} ... P_{4i}$ represent conventional input prices in GH¢ (p_i denotes rent, p_2 represent price of seed per kg, p_3 cost of ploughing per hectare and p_4 is the wage rate). y_i is output of soybeans in kilograms. Also, u_i is farm specific and socioeconomic characteristics related to production efficiency and v_i is random variable associated with disturbances in production.

Farmers' technical and allocative inefficiencies depend on certain farmer-specific, farm-specific and institutional factors. Following Battese and Coelli (1995) the inefficiency effects models (for technical and economic efficiency) are given as follows:

$$\begin{aligned} U_i = \varphi_0 + \varphi_1 \ln Z_1 + \varphi_2 \ln Z_2 + \varphi_3 \ln Z_3 + \varphi_4 \ln Z_4 + \varphi_5 \ln Z_5 + \varphi_6 \ln Z_6 + \\ \varphi_7 \ln Z_7 + \varphi_8 \ln Z_8 + \varphi_9 \ln Z_9 + \omega_i \end{aligned} \tag{14}$$

where $Z_1, Z_2, ..., Z_9$ represent age of farmers in years, sex (female =0, male = 1), farm-home distance in kilometres, educational level of farmers in years, occupation (0 if a farmer, 1 otherwise), membership of farmer-based organization (FBO) (1 if a member, 0 otherwise), access to extension service (1=have access to extension and 0 otherwise), usage of improved soybean seed variety (1 if yes, 0 otherwise) and cropping system (1 if mixed cropping, 0 otherwise) respectively. The parameters of the model, the β_0, the φ_0 and the variance parameters, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$ will be simultaneously estimated using the maximum likelihood.

RESULTS AND DISCUSSION

Farm and Farmers' Characteristics

The demographic and farm characteristics of soybean farms are summarized in Table 1. The average age of farmers in our sample was 31 years, with maximum age being 85 years and a minimum of 16 years. More than half (56.8 per cent) of the respondents had never been to school resulting in a very low average year spent in school of 2.04. The results also report that the mean distance of the farm from farmers' residence was 2.883 km, with a range of 0.3 km to 15 km. This has implications on how strong a farmer will be after travelling such a long distance to the farm to work and sometimes the travel cost that he/she will incur. About 86% of the sampled farmers were males while 13.8% were females. This implies that soybean farming in the Northern Region of Ghana is dominated by males. About 75% of the respondents had farming as their main occupation with the remaining 25.4% being artisans, traders, salary workers, among others.

Group membership is expected to help farmers mitigate existing and potential problems associated with farm inputs acquisition and usage, marketing imperfections to ascertain other relevant and crucial information on farming. It was however, found that less than half (47.6%) of the farmers had membership to FBOs, while the remaining 52.4% did not belong to any economic group. Furthermore, 64.2% of the respondents received extension services while 35.8% did not receive any extension service. The implication is that more than half of the farmers stood the chance of being informed on new farming techniques. On the usage of improved soybean varieties, 88.6% of the respondents used the improved seed varieties, while only 11.4% used their own local seeds. This indicates the dominant use of the improved soybean seeds varieties among soybean farmers in the Northern Region of Ghana.

TABLE 1: FARM AND FARMERS' CHARACTERISTICS

Variable	Units	Mean	Std. Dev.	Min	Max
Output	Kg	918.7	892.127	170	7600
Farm size	Hectares	2.954	1.243	1	8
Seed	Kg	9.189	1.965	2.5	15
Mechanisation	GH¢	194.71	158.37	40	1,100.00
Labour	Man-days	20.289	8.344	3	60
Cost of production	GH¢	1,722.45	2,033.17	103.75	9,422.50
Land price	GH¢	54.11	11.94	40.00	90.00
Seed price	GH¢	1.31	0.65	0.77	3.27
Mechanisation price	GH¢	56.27	15.99	40.00	100.00
Labour price	GH¢	9.98	3.50	4.00	20.00
Age	Years	31.09	10.13	16	85
Sex	1=male, 0=female	0.862	0.345	0	1
Farm-home distance	Km	8.401	3.693	1	16.5
Education	Years of schooling	2.04	4.26	0	23
Occupation	0=farmer, 1=otherwise	0.254	0.436	0	1
FBO	1=own land, 0=otherwise	0.476	0.500	0	1
Access to extension services	1=yes, 0=no	0.642	0.480	0	1
Usage of improve seed variety	1=yes, 0=no	0.886	0.318	0	1
Cropping system	1=mixed cropping, 0=otherwise	0.412	0.493	0	1

Source: Field survey, 2015

An average farmer in the study area realised 918.7 kg of soybean. The size of land under soybean production average 2.954 hectares. The largest farm size cultivated was 8 hectares while the smallest plot size was found to be 1 hectare. Thus, all soybean farmers that were sampled can be considered as small-scale farmers. Regarding the quantity of seed sowed, the results showed that 9.189 kg of seed was sowed per hectare of farm with as high as 15 kg and as low as 2.5 kg sowed per hectare of farm land. Cost of tractor services was used as proxy for level of agricultural mechanization, and it was realised that a farmer incurred an average cost of GH¢ 56.27 to plough a hectare of farm land. Mechanisation price could cost as high as GH¢ 100.00 and as low as GH¢ 40.00 per hectare during the 2015 farming season. An average of GH¢ 194.71 was incurred by a farmer to plough his/her total plots of farmland. However, while some of them incurred as high as GH¢ 1,100.00, others incurred just GH¢40.00 on their plots of farm lands for using tractor services. Averagely, GH¢ 9.98 was paid as hourly wage to labour and could range between GH¢ 4.00 and GH¢ 20.00.

In terms of agrochemical usage, the results showed that only few of the soybean farmers (14.6%) used it, but relatively more farmers used fertilizer (45.2%). An important characteristic of soybean plant is its nitrogen fixing capability through symbiosis with nodulating bacteria in the soil. It has been estimated that up to 50 percent of the total nitrogen of the plant may be supplied by its nitrogen fixing mechanism, hence many farmers in the study area felt fertilizer use is less important.

Again, many of the farmers are low income earners struggling to survive with their little resources. They hardly have access to credit to expand their production and hence they see the opportunity cost of using agrochemicals very high compared to weeding the farm manually using family or communal labour. This makes some smallholders produce on subsistence basis.

Factors Influencing Productivity and Technical Efficiency of Soybean Production

The estimates of the stochastic production and cost frontier models with a translog specification are presented in Table 2. The appropriateness of the functional form of the technical efficiency model was tested using likelihood ratio test, and the translog was found to be appropriate at 1% level with a LR chi2 (9) =191.17 and hence the null hypothesis that Cobb-Douglas production is statistically valid representation of the data ($H_0 : \beta_{ij} = 0$) was rejected. This implies that there is enough evidence that the model is fit and the specified distributional assumption is correct. This is consistent with findings of Shamsudeen, Nkegbe & Donkoh (2013) and Al-hassan (2008) but inconsistent with the findings of Waluse (2012) and Bempomaa & Acquah (2014). The parameter $\gamma = \sigma_u^2 / \sigma^2$ lies between 0 and 1, with value 0 suggesting that technical inefficiency is not present and thus, Ordinary Least Square (OLS) estimation is an adequate representation and a value close or equal to 1 implying that the frontier model is appropriate (Piesse and Thirtle, 2000). The value of gamma, $\gamma = 0.593$ is statistically significant at 1% level hence the null hypothesis that the inefficiency effects is non-stochastic is rejected and therefore, it can be concluded that the socioeconomic factors in the inefficiency model explain the variations in the inefficiency term. The value of the parameter estimate means that total variation of output from the frontier is 59.3% attributed to technical inefficiency. In other words, it implies that more than half of the residual variation is due to the inefficiency effect while 40.7% is due to stochastic effects such as measurement error. It can also be understood to mean that the variances between the actual or observed output and the frontier output had been controlled largely by factors within the control of the farmers (technical inefficiency). The log likelihood ratio for the fitted model was found to be -234.71957 and was strongly significant at 1% level. This implies that the overall model was significant and the explanatory variables that were used in the model jointly explain the variations in the production of soybean. These tests further indicate that inefficiency exists in the data set and therefore, the null hypothesis of no technical inefficiency in Soybean production in the Northern Region of Ghana is rejected.

Adding more to the above evidence, the parameter lamda $\lambda = \sigma_u^2 / \sigma_v^2$ =1.207 was statistically different from zero at 1% level (in terms of the Z-statistics; $Z = \hat{\lambda} / se = 15.68$ is greater than the critical value of $Z_{0.01} = 2.58$) implying that the discrepancies between the observed and the frontier production is dominated by technical differences in inefficiency and hence the use of the frontier production function is appropriate. It also affirms that the one-sided error term (u) dominates the symmetric error (v) and so differences in actual production is as a result of farmers' management practices instead of random variability (Aikaterini, 2010).

The results show that, conventional input variables that significantly affect soybean production in the study area are seed and mechanisation (cost of tractor services). There existed direct relationship between all the inputs in the production function and soybean output. A direct effect of inputs on the output meets our *a priori* expectations of the research. More inputs used in rightful amounts will upturn production. Increase in the use of this explanatory variable (inputs) in the production process would lead to a more than proportionate increase in output. All the variables were mean-corrected except for the socioeconomic variable and hence the coefficients of the input variables are explained as output elasticities.

The input seed was found to be positive (0.482) and significant at 1% level. On average, 100% increase in the quantity of seed sowed strongly increased soybean output by 44%, *ceteris paribus*. Waluse (2012) had similar results and found that, an increase in quantity of seed sowed per hole helps reduce the risk of plants failing to sprout and will therefore translate into higher production per a hectare of farm land.

TABLE 2: PARAMETER ESTIMATES FROM THE STOCHASTIC PRODUCTION FRONTIER MODELS *(DEPENDENT VARIABLE IS OUTPUT, MEASURED IN KG)*

Independent variable	Coefficient	Std. Error
Farm size (hectare)	0.024	0.056
Seed (kg)	0.482***	0.105
Mechanisation (GH¢)	0.686***	0.039
Labour (man-days)	-0.012	0.070
Square of Farm size	-0.220***	0.074
Square of Seed	-0.676***	0.175
Square of Mechanisation	0.045	0.050
Square of Labour	-0.223***	0.079
Farm size – Seed interaction	1.330***	0.207
Farm size – Mechanisation interaction	0.383***	0.075
Farm size – labour interaction	-0.261***	0.083
Seed – Mechanisation interaction	-0.471**	0.188
Seed – labour interaction	0.863***	0.224
Mechanisation – labour interaction	0.387***	0.098
Constant	0.254***	0.044
Sigma-squared: σ^2	0.356***	0.042
Sigma(v): σ_v	0.380***	0.025
Sigma(u): σ_u	0.459***	0.058
Lamda: $\lambda = \sigma_u / \sigma_v$	1.207***	0.077
Gamma: $\gamma = \sigma_u^2 / \sigma^2$	0.593	
Returns to scale	1.115	
LR test of $\sigma_u = 0$:	Chibar2 (01) = 8.44	
Log likelihood = -234.71957	Wald χ^2(14) = 717.53	

Legend: *, ** and *** indicate statistically significant coefficients at 10%, 5% and 1% levels respectively.

Mechanisation was found to be positive (0.686) and significant at 1% level. It had the highest partial elasticity. Increased in mechanisation by 100% will upturn soybean output by 68.6% when all other factors are held constant. Most of the rural and small-scale farmers did not have access to credit and coupled with their low level of income they found it extremely difficult to have their hectares of farm land ploughed with tractor and as a result they either farm late during the farming season and realise lower yields or cheated on the required measurement of a hectare of land to be ploughed due to pressure of competition among the farmers for the limited number of tractors that serve them. This was also revealed during a focus group discussion with some of the farmers. Those especially in the interior villages lamented that their access to tractor services is very low and that in some situations they have to pay extra amounts above the prevailing price per a hectare before their farms will be ploughed. Tractor service providers who were also interviewed indicated that rising cost of fuel is the cause of such high prices. They also complained that they have to incur extra cost in reaching out to these interior and remote farming communities and will have to share that extra fuel cost with the farmers. There is therefore the need for government to regulate fuel prices especially if the country's agricultural sector is to be the engine of growth to propel the needed livelihood of the people of Ghana. Rural farmers could benefit directly via tractor owners from subsidized fuel for ploughing to ensure effective and sustainable mechanization in agricultural production.

The findings also showed a positive coefficient for farm size (0.024) and a negative coefficient for labour (-0.012) but both were not significant at 10% level.

The translog production model had a lot of interaction terms being statistically significant. While some of the coefficients had positive signs, others were found to be negative. "Farm size squared" was negative (-0.22) and statistically significant at 1%, meaning that continuously increasing hectares of farm land by 100% will at a point decrease output by 22%. "Seed squared" was also negative (-0.676) and statistically significant at 1%, implying that continuously increasing the quantity of seed (kg) sowed by 100% will at a point decrease output by 67.6%. "Labour squared" was also seen to be negative (-0.223) and significant at 1% level implying that continuous addition of labour into the production of soybean by 100%, will at a point decrease output by 22%.

The other significant interactive terms show whether the conventional inputs were substitutes or complements. "Farm size and seed", "farm size and mechanisation", "seed and labour" and "mechanisation and labour" were seen to have positive coefficient and significant at 1%. These interactive terms had positive values 1.330, 0.383, 0.863 and 0.387 respectively. They indicate that the input pairs were complements. Similarly, the interactive terms such as "farm size and labour" and "seed and mechanisation" were also found to be significant but the coefficients were negative -0.261 and -0.471 respectively. This means the pairs of those input variables were substitutes.

The return to scale value of 1.18 shows increasing returns to scale. It was arrived after summing up all the output elasticities. It implies that, an increase in the use of the conventional variable inputs such as seed and mechanisation in the production process would lead to a more than proportionate increase in output. A 100% increase in all factors of production will result in 118% upturn in soybean output, *ceteris paribus*. The return to scale is consistent with the findings by Shamsudeen, Nkegbe and Donkoh (2013) and Waluse (2013) who reported increasing returns to scale of 138.3%. This result is however inconsistent to that of Muhammad and Nasser (2007) who found decreasing returns to scale.

The mean technical efficiency in the area under study is found to be 82.7% (see table 4). This presupposes that, on average, soybean farmers are operating at a level which is 17.3% below the production frontier. In other words, on average, soybean farmers in the Northern Region of Ghana are producing 82.7% of the potential frontier output, given the present level of technology and inputs. Alhassan (2008) who had similar studies in northern Ghana on technical efficiency found mean efficiencies of 51.2% and 53.4% for irrigated and non-irrigated rice farms. Abdulai et al. (2013) had a mean technical efficiency estimate for sampled maize farmers in Northern Ghana as 74%. Results from Etwire et al. (2013) who analysed technical efficiency of Soybean farms and its determinants in Saboba and Chereponi Districts of Northern Ghana using a stochastic frontier approach showed a mean technical efficiency estimate of 53 per cent and the return to scale of 0.75. The value of technical efficiency is within the range of 11.7% to 99.9%.

With the abundance of improved farming technologies in recent times, a good number of farmers (26.6%) still have technical efficiency scores less than 80%. The distribution also shows that only 29.4% of the farmers had technical efficiency measure above 90% whereas 6.2% had efficiency score below 50%.

If an average soybean farmer in northern region of Ghana was to reach the TE level of its most efficient counterpart, then the average farmer could enjoy a cost saving of 17.2 % [1-(0.827/0.999x100]. On the other hand, if a farmer on the lowest efficiency is to achieve the highest efficiency, he/she will be able to save about 88.3% of cost [1-(0.117/0.999) x100]. This implies that recognizing and addressing the major factors that constrain efficiency in smallholder soybean production could increase output while applying the current technology.

In the short run, there is the need for the farmers to increase their production by 14.6% through adoption of improved soybean varieties, learning from old soybean farmers, increasing their number of years in schooling and government intensifying access to extension service to the farmers.

Factors Influencing Cost and Economic Efficiencies of Soybean Farmers

The stochastic cost frontier model generally performed well, with a Wald test statistic of 1148.64 (p-value = 0.0000). The value of lambda $\lambda = \sigma_u / \sigma_v$ was found to be 2.20 and significant at 1% level. Hence, the null hypothesis that there is no inefficiency effect is rejected at 1% level, implying there is the presence of inefficiency effects among soybean farmers in the study area. The gamma $\gamma = \sigma_u^2 / \sigma^2$ was found to be approximately 0.829 and significant at 1% level. The parameter gamma measures the total variation of observed cost from the frontier cost. This can be interpreted to mean that the total variation captured by sigma squared, is 82.9% attributed to economic inefficiency while 17.1% of the variation is due to stochastic noise. The difference between the actual cost of production and the possibility of maximum production costs among farmers is 82.9% caused by the differences in economic efficiency and 17.1% caused by stochastic effects such as measurement error (factors beyond the control of the farmer). It is evident that the sigma squared of 1.370 is significantly different from zero. This shows a good fit and the correctness of the specified distributional assumption for the composite error term. It affirms how agricultural production is characterised by uncertainties (Abedullah and Mushtaq, 2007). The translog functional form was found to be appropriate instead of Cobb Douglas and this finding is inconsistent with that of Paudel and Matsuoka (2009) and Zalkuwi, Dia and Dia, (2010). However, the result is consistent with that of Magreta et al. (2013).

In the translog cost function, the estimated coefficients show relative change in cost of soybean production (C_i), resulting from a proportionate change in the explanatory variable. Since all the variables, except the socioeconomic factors were mean-corrected, the coefficients of the cost function are explained as cost elasticity of soybean production. Just like the case of the output model the partial elasticity for the price paid for mechanisation was found to be the most important determinant of cost in producing soybean. A 100% increase in price paid for mechanisation results in 101.7% increase in the cost of production, all other things been equal. While all the coefficients had positive signs, only seed price and mechanisation price were significant at 1% level with the rest not being significant even at 10% level. Hence these explanatory variables are the important determinants of soybean production in northern region of Ghana.

TABLE 3: MAXIMUM-LIKELIHOOD ESTIMATES OF THE PARAMETERS OF THE STOCHASTIC COST FUNCTION

Total production cost	Coefficient	Std- Error
Constant	-0.185	0.146
Land price	0.163	0.219
Seed price	1.013***	0.117
Tractor price	1.017***	0.168
Labour price	0.080	0.121
Square of Land price	-3.142***	0.787
Square of Seed costs	-2.026***	0.315
Square of Tractor price	-1.678***	0.544
Square of Labour price	0.424**	0.196
Land price-seed price interaction	-0.194	0.445
Land price – tractor price interaction	-2.062***	0.645
Land price-labour price interaction	1.245***	0.417
Seed price- tractor price interaction	0.707**	0.337
Seed price-labour price interaction	0.410*	0.227
Tractor price-labour price interaction	-0.462	0.389
Output	1.172***	0.080
Square of Output	-0.960***	0.094
Output – Land price interaction	0.349	0.304
Output – Seed price interaction	0.689***	0.144
Output – Tractor price interaction	0.544**	0.233
Output – Labour price interaction	0.275*	0.155
Sigma-squared; σ^2	1.370***	0.195
Sigma(v); σ_v	0.484 ***	0.074
Sigma(u); σ_u	1.066***	0.119
Lamda; $\lambda = \sigma_u / \sigma_v$	2.200***	0.188
Gamma; $\gamma = \sigma_u^2 / \sigma^2$	0.829	
LR test of $\sigma_u = 0$:	Chibar2 (01) = 9.04	
Log likelihood= -557.60495	Wald χ^2 (20) = 1148.64	

Legend: *, ** and *** indicate statistically significant coefficients at 10%, 5% and 1% levels respectively.

The positive coefficient of price paid for seed implies that an increase in price of seed by 100% will result in an increase in cost of soybean production by 101.3%. Similarly, an increase in cost of machinery per a hectare of land by 100% will upturn the total production cost by 101.7%. Output in kg was also found to increase total cost of production by 117.2% for a 100% increase in output.

Most of the squared and interaction terms were statistically significant at 1% level, implying that the translog function is appropriate. Among the second order terms, the coefficients of the squared term for land price, seed price, tractor price, output and that of interactions of land price and tractor price were negative and highly significant at 1% levels showing an inverse relationship with total cost of production. Also, most of the interaction terms had positive significant coefficients. The only terms that had negative coefficients were as follows: land price and seed price; land price and tractor price; and tractor price and labour price. Generally, the results confirm the complementarity or substitutability of the factors of the production as discussed earlier.

The economic efficiency scores for the soybean farms in the study area are presented in Table 4. The range of economic efficiency is high indicating that there is a huge gap between the lowest and highest economic efficiency indices. The economic efficiency of an average soybean farm was estimated as 0.495 meaning that an average soybean farmer in the study area experiences economic efficiency that is 50.5% below the frontier. About half (49%) of the farmers are found to have economic efficiency scores of less than 50% while just a few of the farmers (1.8%) had economic efficiency above 80%. The result of the average economic efficiency is low compared to Magreta, Edriss, Mepemba, & Zingore (2013), Degefa (2014) and Shalma (2014) who had 53.32%, 54% and 64.7% respectively. Again, Akhilomen, Bivan, Rahman, & Sanni (2015) who analysed economic efficiency of pineaple production had a mean economic efficieincy of 64.3%. However, the findings in this study is relatively higher than the results obtained by Beshir, Emana, Kassa, & Haji (2012) who had 28.9%.

The result also indicates that the farmer with average level of economic efficiency would enjoy a cost saving of about 42% (i.e., 1- (0.495/0.854) x100) to attain the level of the most efficient household. The most economically inefficient household would have an efficiency gain of 95.2% derived from (1- (0.041/0.854) x100) to attain the level of the most efficient household.

TABLE 4: FREQUENCY DISTRIBUTION OF TECHNICAL, ECONOMIC AND ALLOCATIVE EFFICIENCY SCORES

	Technical efficiency		*Economic efficiency*		*Allocative Efficiency*	
Score range	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
≤ 0.30	14	2.80	90	18.00	51	10.20
0.31 – 0.40	7	1.40	87	17.40	48	9.60
0.41 – 0.51	10	2.00	68	13.60	73	14.60
0.51 – 0.60	11	2.20	66	13.20	61	12.20
0.61 – 0.70	17	3.40	89	17.80	80	16.00
0.71 – 0.80	74	14.80	91	18.20	90	18.00
0.81 – 0.90	220	44.00	9	1.80	85	17.00
> 0.90	147	29.40	0	0	12	2.40
Minimum	0.117		0.041		0.068	
Maximum	0.999		0.854		0.987	
Mean	0.827		0.495		0.595	
Std. Deviation	0.164		0.201		0.208	

Source: Author's field survey data, 2015

Again from table 4, mean allocative efficiency level among the farmers in northern region of Ghana is estimated to be 59.5%, with standard deviation of 20.8%. This indicates that there is a great opportunity to increase the efficiency of soybean producers by the reallocation of resources in cost minimizing way. There exists a huge gap between the lowest and highest allocative efficiency indices (range of 6.8% – 98.7%).

The mean allocative efficiency level is low compared to that of Ajao, Ogunniyi, & Adepoju (2012); Akhilomen, Bivan, Rahman, & Sanni (2015); Magreta, Edriss, Mepemba, & Zingore (2013); Degefa (2014) but relatively higher than the findings obtained by Khai & Yabe (2011); Beshir, Emana, Kassa, & Haji (2012). The allocative efficiency estimates presented in Table 4, suggest that an average soybean would enjoy a cost saving of 39.7% derived from [1 – (0.595/0.987)) x 100] if he/she were to attain the level of the most efficient farmer. The most economically inefficient farmer would have an efficiency gain of 93.1% derived from [1-(0.068/0.987) x 100] to attain the level of the most efficient farmer. Economic efficiency in smallholder soybean farming system could be increased by 50.5% using the current level of production technology. This implies that smallholder productivity could double if key factors that currently constrain overall efficiency are addressed adequately.

Determinants of Technical and Economic Inefficiency in Soybean Production in Northern Ghana

The results of the analysis of factors influencing technical and economic inefficiency are shown in Table 5. The results show an inverse and significant effect of farmers' age on technical and economic efficiencies both at 1% level. Older farmers are technically and economically less efficient than younger farmers. It may be that, older farmers often form habit of using old and traditional cultural practices and they do not easily adopt new practices and modern inputs. Moreover, younger farmers may be more active in present and modern agricultural practices than older farmers. This result is in conformity with the findings by Latt, Hotta, & Nanseki (2011) and Yegon, Kibet, & Lagat (2015). The finding however contradicts results made by Ajao, Ogunniyi, & Adepoju (2012), Otitoju, Adebo, & Arene (2014), Paudel & Matsuaka (2009).

The parameter estimate for the farm-home distance is positive for technical and economic efficiency but significant at 10% for only economic efficiency. Farmers whose farms are far apart from their residence and thus travels long distance to their farms tend to be less economically efficient. Long distance from home to farm means the farmer incurs more cost in travelling to the farm and also risks the danger of becoming more exhausted before reaching the farm. According to Sienso et al. (2013), who also had similar findings, the more time a farmer spends in travelling to the farm the higher the probability of the farmer getting tired and thus the less the time that will be available for farm work which in turn reduces efficiency.

Education had a negative influence on technical and economic inefficiency but significant for only technical efficiency. This implies that the more years the farmer spends in schooling the higher his/her technical efficiency. Increase in number of years of schooling by a farmer enriches the farmer's knowledge, skill and attitude and makes him/her more likely to adopt new technologies (Ogundari, S.O, & I.A., 2006) and best practices. This has met the *a priori* expectations. It could also be taken to mean that educated farmers can use information from various sources and undertake more informed decisions compared to their low educated counterparts to improve the farm management and hence, their greater efficiency on soybean production (Mengistu, 2014). In line with this study, research done by Muhammad & Nasser (2007) in Peshawar District of Pakistan also found education to influence Technical efficiency positively and significantly. The results however contradict that of the one found by Chirwa (2007).

TABLE 5: DETERMINANTS OF TECHNICAL AND ECONOMIC INEFFICIENCY

Independent Variables	*Technical inefficiency model*		*Economic inefficiency model*	
	Coefficient	**Z**	**Coefficient**	**Z**
Constant	-11.368**	-2.43	-0.656	-0.85
Age	0.123***	5.97	0.048***	3.34
Sex	6.897	1.50	-0.414	-1.37
Farm-home-distance	0.065	1.01	0.055*	1.69
Education	-0.259***	-3.79	-0.012	-0.39
Occupation	0.277	0.44	-0.251	-0.68
FBO	0.320	1.05	-0.168	-0.87
Access to extension services	-1.253***	-3.30	-0.884***	-3.09
Usage of improve seed variety	-1.912***	-5.64	-0.836**	-2.42
Cropping system	0.248	0.61	0.555**	2.18

Legend: *, ** and *** indicate statistically significant coefficients at 10%, 5% and 1% levels respectively.

Source: Author's field survey data, 2015

Access to extension service was found to be negative and significant in influencing technical and economic inefficiencies. Extension service is expected to increase the farmer's know-how on some agronomic practices such as pest and disease control and adoption of improved seed varieties as well as soil and water conservation technologies. This puts the framer in the better position to utilise his/her limited resource to achieve higher results and hence increase their technical efficiencies.

The variety of soybean the farmers in the study area sowed was found to have negative coefficient and significant at 1% level for technical efficiency and 5% level for economic efficiency. This means that farmers who used improved seed varieties were more efficient than those who used local and unimproved seed varieties.

The type of cropping system the farmers in the study area employed tend out to positively and significantly influence economic efficiency. It was however not significant for the technical efficiency though it also had positive sign. The positive effect of the variable on economic inefficiency is contrary to the *a priori* expectation of the study. Although soybean is known to have the potential of fixing nitrogen into the soil, intercropping it with other crops such as maize means that it would compete with the latter for air, space and other nutrients. This implies extra costs of manure and other farm management practices

CONCLUSION AND RECOMMENDATIONS

Among the three types of efficiencies, technical efficiency was highest, followed by allocative efficiency, then economic efficiency. Technical and allocative efficiencies are not an end in themselves, economic efficiency is. The low economic efficiency is as a result of the low allocative efficiency. The low allocative efficiency is also as a result of high input prices such as costs of seed and tractor services. From the constraints, the farmers' problems border on soil infertility and erratic rainfall, which have meant that they must spend a lot on inputs such as manure and others that will sustainably improve soil fertility and labour, for which they have inadequate capital. However, being relatively young, having access to education and extension services as well as living closer to the farm increase farmers' efficiency.

There is undeniable fact that soybean has great potential of uplifting the fortunes of the people of Northern Ghana and the nation at large in relation to food, nutrition, health, dependable alternative source of income and improvement of soil fertility through its biological nitrogen fixation, etc. High profitability has been demonstrated with improved practices and value addition. Conversely, the achievement of the potential the country is endowed with will largely hinge on a steady effort that will curb problems not only on production and cost inefficiencies but also soybean value-chain, including processing and value-addition at all levels. In that light, effective linkage with large-scale feed and food processors will help much in the achievement of the potentials.

The following recommendations could together decrease technical, allocative and economic inefficiencies so as to increase productivity and profitability of soybean farmers given the above empirical findings:

It is essential for MoFA, Non-Governmental Organisations (NGOs) and institutions of learning to inspire the youth to join in soybean farming and consider farming as a business so that they can move from being smallholders to larger scale farmers with the business oriented motive through project initiations and education. The Government of Ghana's policy of Youth in Agriculture should be re-vitalised and focus greatly on soybean production as a promising alternative source of income for the large pool of unemployed youth.

Farmers whose farms were far away from their homes were found to be less economically efficient than those who were near to home. Perhaps, those farmers incurred high travelling cost to their farms and thus adding more to cost of production than those whose farms were near their home. Government is therefore expected to reduce and stabilise fuel prices to lessen the transportation cost of these poor struggling rural and subsistent farmers.

Similarly, government should invest more in education in general and farmer education (both formal and informal) in particular and at the same time deal with regulation of farm input prices so that their know-how on the best practices would be built to achieve high yield with their limited resources available.

Another policy implication of the study is in the area of access to extension service. Extension services should be increased to farmers by the government agents especially District Agriculture Development Unit, and NGO's to assist these farmers to have easy access to extension so as to increase farm efficiencies. Existing extension agents should be motivated and given more training to effectively reach out to the farmers to impact the needed information the farmers need to improve efficiency.

Furthermore, research institutions such as CSIR/SARI, University for Development Studies and other Institutions of learning should increase production of certified but improved seed varieties. These varieties should be produced at the lowest possible cost so as to make them affordable to the farmers. It also behoves the agricultural extension officers to encourage farmers to use the improved and certified seeds if they really want to fully utilize the potentials.

Lastly, challenges such as inadequate capital and high input price should be given proper consideration through encouraging farmers to save and plough back profits, extension of affordable interest loan facilities and adoption of smart subsidies approach that will focus on minimizing distortions in general prices of goods and services and maximizing benefits. There is high value in having a coherent strategy with a policy on tackling constraints of inadequate capital and high input prices being the lead in agricultural development.

REFERENCES

Addai, K. N. 2011. *Technical efficiency of maize producers in three agro ecological zones of Ghana.* Kumasi: Kwame Nkrumah University of Science and Technology.

Aigner, D., Lovell, K. C., & Schmidt, P. 1977. Fomulation and estimation of stochastic frontier production function models. *Journal of Econometrics 6*, 21-37.

Aikaterini, K. 2010. Estimating technical inefficiency: An empirical approach to EU industries. *Regional Science Inquiry Journal*, Vol. II (2) 95-104.

Ajao, A. O., Ogunniyi, L. T., & Adepoju, A. A. 2012. Economic efficiency of soybean production in Ogo-Oluwa Local Government Area of Oyo State, Nigeria. *American Journal of Experimental Agriculture*, 2(4): 667-679.

Akhilomen, L. O., Bivan, G. M., Rahman, S. A., & Sanni, S. A. 2015. Economic efficiency analysis of pineapple production in Edo State, Nigeria: A stochastic frontier production approach. *American Journal of Experimental Agriculture* 5(3), 267-280.

Atiim, P. 2011. *Assessment of postharvest losses in soybeans production in the Builsa District in the Upper East Region and Savelugu District in the Northern Region of Ghana.* Kumasi: Kwame Nkrumah University of Science and Technology.

Atkinson, S., & Cornwell, C. 1994. Parametric estimation of technical and allocative inefficiency with panel data. *International Economic Review, 35*, 231-243.

Battese, E. G., & Coelli, J. T. 1995. A model of technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics, 20*, 325–32.

Battese, G. (1992). Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics. *Agricultural Economics, 7*, 185-208.

Bauer, P. 1990. A survey of recent econometric developments in frontier estimation. *Journal of Econometrics, 46*, 21–39.

Bempomaa, B., & Acquah, H. d.-G. 2014. Technical efficiency analysis of maize production:Evidence from Ghana. *Agroinform Publishing House, Budapest*, 73-79.

Beshir, H., Emana, B., Kassa, B., & Haji, J. 2012. Economic efficiency of mixed crop-livestock production system in the north eastern highlands of Ethiopia: the Stochastic frontier approach. *Journal of Agricultural Economics and Development.* 1(1), 10-20.

Boumans, G. 1985. *Grain handling and storage.* B. V. Amsterdam, Netherland: Elsevier Science Publication. Vol. 4.

Chimai, B. C. 2011. *Determinants of technical efficiency in smallholder sorghum farming in Zambia.* Columbus, Ohio: Ohio State University.

Chiona, S. 2011. *Technical and allocative efficiency of smallholder maize farmers in zambia.* Lusaka: University of Zambia.

Chirwa, E. W. 2007. Sources of technical efficiency among smallholder maize farmers in southern Malawi. *The African Economic Research Consortium*, 13-14.

Citifmonline. 2015. (October 8). *Citifmonline news*. Retrieved 11 18, 2015, from Citifmonline: http://www.citifmonline.com/2015/10/08/bill-melinda-foundation-legumes-farming-in-ghana/

Cochran, W. 1963. *Sampling Techniques*. *2nd Ed.* Yew York: Jphn Wiley and sons, Inc.

Coelli, J. T., O'Donnell, C. J., & Battese, G. E. 2005. *An Introduction to Efficiency and Productivity Analysis.* New York: Springer Science + Business Media.

Coelli, J. T., Prasada, R., & Battese, G. 1998. *An Introduction of Efficiency and Productivity Analysis.* Boston: Kluwer Academic Press.

Coelli, T. 1996. Specification and estimation of stochastic frontier production function. Australia: Unpublished PhD Dissertation, University of New England.

Coelli, T. J. 1995. Recent developments in frontier modelling and efficiency measurement. *Australian Journal ofAgricultura1 Economics.* 39 (3), 219-24.

Coelli, T., Rahman, S., & Thirtle, C. 2002. Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: A non-parametric approach. *Journal of Agricultural Economics*, 533607-606.

Dapaah, H. K., Ennin, S., & Asafu- Agyei, J. 2005. Soybean management for increased production: Effects of plant population density and planting method. *Ghana Journal Agricultural Science*, 1.

Debertin, D. L. 2012. *Agricultural Production Economics,* Second Edition. Upper Saddle River, N.J. USA: Pearson Education, Corporate Editorial Offices.

Degefa, K. 2014. Economic efficiency of smallholder farmers in maize production in Bako Tibe District, Oromia National Regional State, Ethiopia. Haramaya: School of Agricultural Economics and Agribusiness, School of Graduate Studies of Haramaya University.

Deprins, L. D., Simar, L., & Tulkens, H. 1984. Measuring labor-efficiency in post offices. In: M. Marchand (Ed.), *The Performance of Public Enterprises: Concepts and Measurement,* pp. 243-267. Amsterdam: Elsevier.

Dinc, M., Haynes, K., Stought, R., & Yilmaz, S. 1998. Efficiency versus penteration. *Telecommunications Policy, Haynes,* Vol. 22, 541-553.

Etwire, P. M., Ibrahim, A. D., Samuel, B. S., Alhassan, A. L., Afia, K. S., & Peter, A. 2013. Analysis of the seed system in Ghana. *International Journal of Advance Agricultural Research*, 9.

Etwire, P. M., Martey, E., & Dogbe, W. 2013. Technical efficiency of soybean farms and its determinants in Saboba and Chereponi Districts of northern Ghana: A stochastic frontier approach. *Sustainable Agriculture Research,* 2 (4), 106-116.

Farrell, J. M. 1957. The Measurement of productive efficiency. *Journal of the Royal Statistical Society,* Series A (General), 120 (3), 253-290.

FAO. 2012. *Food and Agriculture Organisation in Developing Countries.* Rome, Italy: State of food and agriculture.

Forsund, R. F., Lovell, C. A., & Schmidal, P. 1980. A survey of frontier production functions and of their relationships to efficiency measurement. *Journal of Econometrics,* 13, 5-25.

Frisvold, G., & Ingram, K. 1994. Sources of agricultural productivity growth and stagnation in Sub-Saharan Africa. *Agricultural Economics* 13, 51-61.

GNA, G. 2012, (December 22). *CSIR releases eight new maize and soybean varieties to farmers*. Retrieved June 2, 2015, from Business and Economics: http://www.ghananewsagency.org/economics/csir-releases-eight-new-maize-and-soybean-varieties-to-farmers-54222

Greene, W. 1993. *The Econometric Approach to Efficiency Analysis in The Measurement of Productive Efficiency.* Oxford: Oxford University Press.

Greene, W. H. 1980. Maximum likelihood estimation of econometric frontier functions. *Journal of Econometrics,* 13 (1), 27-56.

Greene, W. H. 2008. The econometric approach to efficiency analysis. *Fried: Chap02*, 92-250.

GSS. 2013. *2010 Population and Housing Census; Regional Analytical Report; Northern Region. Ghana.* Ghana Statistical Service.

Huang, C. J., & Liu, J.-T. 1994. Estimation of a non-neutral stochastic frontier production function. *Journal of Productivity Analysis*. 5, 171–180.

Ibgekele, A. A. 2008. An evaluation of parametric and non-parametric methods of technical efficiency measurement: Application to small scale food crop production in Nigeria. *Journal of Agriculture and Social Science*. 95-100.

Khai, H. V., & Yabe, M. 2011. Productive efficiency of soybean production in the Mekong River Delta of Vietnam, Soybean. In: T.-B. N. Prof., *Applications and Technology* (pp. ISBN: 978-953-307-207-4,). Vietnam: InTech, Available from: http://www.intechopen.com/books/soybean-applications-and-technology/productiveefficiency-.

Khai, H. V., Yabe, M., Yokogawa, H., & Sato, G. 2008. Analysis of productive efficiency of soybean production in the Mekong River Delta of Viet Nam. *Journal of the Faculty of Agriculture, Kyushu University.* 58 (1), 271-279.

Kopp, R. J., & Diewert, W. E. 1982. The decomposition of frontier cost function deviations into measures of technical and allocative efficiency. *Journal of Econometrics.* 19 (2-3), 319-331.

Kopp, R. J., & Smith, V. 1980. Frontier production function estimates for steam electric generation: a comparative analysis. *Southern Economic Journal.* 46 (4), 1049-1059.

Kumbhakar, C. S., Ghosh, S., & McGuckin, T. J. 1991. A generalised production frontier approach for estimating determinants of inefficiency in U.S. diary farms. *Journal of Business and Economics Statistics.* 9, No.3, 287-296.

Latt, A. K., Hotta, K., & Nanseki, T. 2011. Analysis of technical efficiency of monsoon rain–fed sesame production in Myanmar: A stochastic frontier approach. *J. Fac. Agr., Kyushu Univ.* 56 (1), 177–184.

Liu, K. 1997. *Soybeans: chemistry, technology, and utilization.* New York: Chapman & Hall.

Magreta, R., Edriss, A. K., Mepemba, L., & Zingore, S. 2013. Economic efficiency of rice production in smallholder irrigation schemes: A case of Nkhate Irrigation Scheme in southern Malawi. *4th International Conference of the African Association of Agricultural Economics*. Hammamet, Tunisia:

Maphouse Ghana Ltd. 2014. *Administrative Atlas of Ghana.* Accra: XCHIP COMMUNICATION.

Martey, E., Dogbe, W., Etwire, P. M., & Wiredu, A. N. 2015. Impact of farmer mentorship project on farm efficiency and income in rural Ghana. *Journal of Agricultural Science,* 7 (10). 79-93

Mbanasor, J. A., & Kalu, K. C. 2008. Economic efficiency of commercial vegetable production system in Akwa Ibom State, Nigeria: A translog stochastic frontier cost function approach. *Tropical and Subtropical Agroecosystems.* 8, 313- 318.

Mburu, S., Ackello-Ugutu, C., & Mulwa, R. 2014. Analysis of economic efficiency and farm size: a case study of wheat farmers in Nakuru District, Kenya. *Economics Research International* .Vol. 2014, 10.

Meeusem, W., & Van Den Broeck, J. 1977. Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review.* 18, 435-44.

Mengistu, G. 2014. Technical efficiency in onion production: The case of smallholder farmers in Dugda Woreda, East Shewa Zone, Ethiopia. Haramaya: Haramaya University, School of Graduate Studies.

MiDA. 2010. *Invest met Opprtunity Ghana; Maize, Soya and Rice.* Accra: Millennium Development Authority.

MoFA. 2010. *Annual Report.* Accra, Ghana: Policy Planning, Monitoring and Evaluation Directorate.

Muhammad, S., & Nasser, K. A. 2007. Measurement of economic efficiencyin agriculture of Peshawar District. *Sarhad Joura of Agriculture*. 23 (1) 201.

Murillo-Zamorano, L. R. 2004. Economic efficiency and frontier techniques. *Journal of Economic Surveys.* 18 (1), 34-63.

Obwona, M. (2006). Determinants of technical efficiency differentials among small and medium scale farmers in Ugenda: A case of tobacco growers. *African Economic Research Consortium.* Nairobi: Research paper No. 152.

Ogundari, K., S.O. Ojo., & I.A., A. 2006. Economics of scale and cost efficiency in small scale maize production: Empirical evidence from Nigeria. *Journal of Social Sciences*, 131–136.

Olayiwola, O. O. 2008. Technical efficiency of soybean Production in Ijebu-Ode Local Government Area of Ogun State, Nigeria. *International Monthly Refereed Journal of Research In Management & Technolog,* Volume 11, 7-13.

Oliver, W. W. 2015. *Determinants of technical efficiency of soybean production among farmers in Bungoma County, Kenya.* Kenya: Moi University.

Otitoju, M. A., Adebo, G. M., & Arene, C. J. 2014. Identification and stochastic analysis of factors influencing technical inefficiency of Nigerian smallholder soybean farmers. *Tropiculturat.* 32, 4, 197-204.

Parikh, A., Ali, F., & Shah, M. K. (1995). Measurement of economic efficiency in Pakistani agriculture. *American Journal of Agricultural Economics.* 77 (3), 675-685.

Paudel, P., & Matsuoka, A. 2009. Cost efficiency estimates of maize production in Nepal: a case study of the Chitwan district. *Agric. Econ.-CZECH*, 139-148.

Radam, A., Yacob, M. R., & Muslim, H. M. 2010. Technical efficiency of the Malaysian wooden furniture industry: A stochastic frontier production approach. *International Business Research*, 10-13.

Reifschnieder, D., & Stevenson, R. 1991. Systematic departures from the frontier: A framework for the analysis of firm inefficiency. *International Economic Review,* 32, 715-723.

Richetti, A., & Reis, P. R. 2003. The soybean production frontier and economic efficiency in Mato Grosso do Sul, Brazil. *Rev. Econ. School*, Rural 41 (1).

Sanful, R. E., & Sophia, D. 2010. Utilization of soybean flour in the production of bread. *Parkistan Journal of Nutrition*, 2.

Sanyang, B. S. 2014. Evaluation of technical, allocative and economic efficiency of rice producers: A case study in Central River Region, North & South of the Gambia. M.Phil Thesis Kumasi: Kwame Nkrumah University of Science and Technology.

Schmidt, P. 1985-86. Frontier Production functions. *Econometric Review*. 4, 289-328.

Seidu, A.-h. (2008). Technical efficiency of rice farmers in northern Ghana. *African Economic Research Consortium, Nairobi*, AERC Research Paper 178.

Serraj, R., & Adu-Gyamfi, J. 2004. Role of symbiotic nitrogen fixation in the improvement of legume productivity under stressed environments. *West African Journal of Applied Ecoogy,* Vol 6, 95-109.

Seyoum, E., Battese, G., & Fleming, E. 1998. Technical efficiency and productivity of maize producers in eastern Ethiopia: A study of farmers within and outside the Sasakawa-Global 2000 Project. *Agricultural Economics*, 341-348.

Shahzad, K. A., & Khalid, M. 2007. Analysis of technical efficiency of rice production in Punjab(Pakistan): Implications forfuture investment strategies. *Pakistan Economic Social Review.* 45, 231–244.

Shalma, H. J. 2014. *Economic analysis of soya bean production under Sasakawa Global 2000 Project in Kaduna State, Nigeria.* Zaria, Nigeria: Ahmadu Bello University.

Shamsudeen, A., Nkegbe, P. K., & Donkoh, S. A. 2013. Technical efficiency of maize production in northern Ghana. *African Journal of Agricultural Research*, 5255.

Sharma, K., Leung, P., & Zaleski, H. 1999. Technical, allocative and ecoomic efficiencies in swine production in Hawaii. *Journal of Agricultural Economics*. 20 (1), 23-35.

Shurtleff, W., & Aoyagi, A. 2009. *History of Soybeans and Soyfoods in Africa (1857-2009).* Lafayette, USA: Soyifo Centre.

Sienso, G., Samuel, B. A., & Amegashie, P. 2013. Estimating the efficiency of maize farmers in ghana. *4th International Conference of the AAAE*.. Cape Town, Hammamet, Tunisia.

SRID, S. 2011. *Comparison of 2009 and 2010 Production Estimates - Legumes ('000 MT).* Accra, Ghana: Ministry of Food and Agriculture.

Tolon District Assembly. 2006, (October 8). *Soybean open up new opportunities*. Retrieved June 1, 2015, from News: http://www.tolonkumbungu.ghanadistricts.gov.gh/?arrow=nws&read=19404

Tweneboah, C. 2000. *Modern Agriculture in the Tropics with Special Reference to Ghana.* Accra, Ghana: Co-Wood Publishers.

Uri, N. D. 2001. Technical efficiency, allocative efficiency, and the implementation of a Price Cap Planin Telecommunications in the United States. *Journal of Applied Economics, Vol. IV, No. 1*, 163-186.

USDA, U. S. 2016. *World Agricultural Production.* Washington, DC: FAS International Production Assessment Division.

Wadud, M. A. 2013. Impact of microcredit on agricultural farm performance and food security in Bangladesh. *Institute of Microfinance Working Paper No. 14*.

Walden, J. B. 2010. Estimating fishing vessel capacity: A comparison of nonparametric approaches. *Marine Resource Economic Review* Vol. 25, 23-36.

Waluse, K. S. 2012. *Determinants of common bean productivity and efficiency: a case of smallholder farmers in eastern Uganda.* Uganda: Masters Thesis. Economics of Egerton University.

Wikipedia. 2016, (April 16). *Wikipedia*. Retrieved April 16, 2016, from Wikipedia: https://en.m.wikipedia.org/wiki/Economies_of_scale

Yegon, P. K., Kibet, L. K., & Lagat, J. K. 2015. Determinants of technical efficiency in smallholder soybean production in Bomet District, Kenya. *Journal of Development and Agricultural Economics.* 7 (5), 190-194.

Zalkuwi, J. W., Y. Z., D., & R. Z., D. 2010. Analysis of economic efficiency of maize production in Ganye area Adamawa State, Nigeria. *Report and Opinion*, 2 (7): 1-9.