An Examination of Profit Inefficiency of Rice Farmers in Northern Ghana

Awudu Abdulai* and Wallace E. Huffman**

*Awudu Abdulai
Swiss Federal Institute of Technology
Dept. of Agricultural Economics
Sonneggstrasse 33
8092 Zurich, Switzerland
(tel: 01-632-5328; e-mail: abdulai@iaw.agrl.ethz.ch)

**Wallace E. Huffman
Department of Economics
Iowa State University
Ames, IA 50011-1070
(tel: 515-294-6359; e-mail: whuffman@iastate.edu)

Respectively, the authors are Visiting Scholar and Professor of Economics and Agricultural

Economics, Department of Economics, Iowa State University, Ames, IA 50011.

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Abstract

This paper employs a stochastic frontier model to examine profit inefficiency of rice farmers in the Northern Region of Ghana using farm-level survey data. The efficiency index, based on a half-normal distribution of the stochastic error term is related to farm and household characteristics. The empirical results show that farmers' human capital represented by the level of schooling contributes positively to production efficiency, suggesting that investment in farmers' education improves their allocative performance. Access to credit and greater specialization in rice production, are found to be positively related to production efficiency. A farmer's participation in nonfarm employment and being older, however, reduce production efficiency. Farmers located in areas with better facilities like extension services and agricultural input delivery systems also tend to exhibit greater production efficiency.

Key words: Africa, Ghana, production efficiency, profit frontier, rice.

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Introduction

Increasing agricultural productivity and employment in Sub-Saharan African countries has received widespread attention in the literature on economic development and poverty alleviation. Agricultural growth on the other hand, is linked to farm profits. Over the past years, considerable research examined efficiency in agriculture in the region (e.g., Moock, 1973; Hopcraft, 1974; Lipton, 1988). This issue has gained more attention in the light of structural adjustment programs— involving market liberalization, fiscal austerity, and currency devaluation—currently under implementation in many countries in the region, and global trade liberalization being pursued under the World Trade Organization (Jayne et al., 1994; Savadogo et al., 1994; Udry et al., 1995; Adesina and Djato, 1996).

In particular, the experience of structural adjustment programs since the beginning of the 1980s shows how important farm household efficiency is to African rural economy. The fundamental role concept of structural adjustments was to enable private markets to perform better by eliminating the dominant public sector, encouraging the development of the private sector, and letting prices perform their signaling role for the allocation of factors of production, good and services. One of the main explanations for previous failures to intensify food crop production in the region has been poor public policies including subsidizing cereal imports which penalizes domestic cereal production.

Under structural adjustments, changes in the fiscal environment that reduce subsidies on food items are supposed to make agriculture more profitable. However, the reduction or removal

of subsidies on agricultural inputs such as fertilizer, fuel or machinery tend to increase the prices of these inputs to farmers. Available evidence shows that the responses of agriculture to these policy reforms have been encouraging as output and productivity have increased in countries that pursued the reforms relative to countries with small change in policies (Abdulai and Hazell, 1995).

Although considerable efforts have been directed at examining efficiency of farmers in the region, particularly during this unfolding process of agricultural and economic reforms (Evenson and Mwake, 1997; Bindlish and Evenson, 1993; Adesina and Djato, 1996), little attention has been given to the relationship between market indicators, household characteristics and production efficiency. This contrasts greatly with the increasing number of such studies in other developing regions and developed countries. Examples of such studies include Huffman (1974, 1977) and Stefanou and Saxena (1988) for the United States, Ali and Flinn (1989) for Pakistan, Kumbhakar and Bhattacharyya (1992) for India, and Bravo-Ureta and Evenson for Paraguay (1994). If we can establish a better understanding of how market indicators and household characteristics affect production efficiency, policy makers can better implement measures that contribute to enhancing agricultural efficiency. The significance of such policies in the phase of increasing competition between domestic and imported agricultural products need not be over-emphasized.

The primary objective of this paper is to derive a statistical measure of profit inefficiency of rice farmers in the Northern Region of Ghana using a stochastic profit frontier and then to examine the relationship between farm and household attributes and production inefficiency. The central hypothesis is that farmers' schooling, specialization in rice production, and access to credit are positively related to rice farmers' efficiency. After a brief description of rice production in

Ghana in section 2, section 3 lays out the model of efficiency. The results of the estimations and discussions are presented in section 4. The final section of the paper summarizes the findings and discusses their implications.

Rice Production in Ghana

Rice production has increased substantially over the last three decades. Annual production averaged 80,000 tons in the last ten years, as compared to an average of about 32,000 tons in the 1960s. Increases in total output are mainly due to land area expansion, with yield gains playing a minor role. Area expansion took place mainly in the Northern region, although irrigation projects are gradually transforming the Accra-Keta coastal plain into a rice growing area. Imported rice still accounts for a large proportion of domestic consumption, because local production falls short of domestic demand (FAO, 1996). The Ghana Seed Company which maintains contact with national and international research institutes has proved improved varieties of Oriza sativa, originally introduced into the country from Asia. The improved varieties that are presently cultivated in Northern Ghana (GR 18 and GR 19) have virtually the same yield potentials (Ghana Seed Company, 1988). Although considerable efforts have been put into increasing rice yields in the country, adverse weather conditions and low input use still keep average yields low.

As in most countries, the government consistently regulated agricultural supply and prices by intervening in both input and output markets until 1984. The rice sector, which experienced a relatively free trade regime during the 1950s and 1960s, saw restrictions being imposed on imports in 1970s to encourage domestic production. The Food Distribution Corporation controled the price of imported rice at distribution centers, and official prices were set for domestic rice

between 1974 and 1983. The overvaluation of the Ghanaian currency contributed to an increase in protection of the rice sector, between 1974 and 1983. Protection of the sector decreased substantially in 1984 and again in 1985 as the exchange rate was successfully devalued. The liberalization of food trade and imports of agricultural inputs such as fertilizers and pesticides exposed the sector to competition with imported rice. The devaluation of the currency, however, made imported rice relatively more expensive than domestic rice, giving domestic producers a competitive edge. Imported rice was about 10% cheaper than domestic rice before the adjustment programs in 1983 and over 25% more expensive at the wholesale level after 1984 (Alderman and Shively, 1996).

Modeling Efficiency

Defining efficiency

The question of how to measure efficiency has received considerable attention in economic literature. Following the work of Farrell (1957), efficiency can be defined as the ability to produce a given level of output at lowest cost. The concept of efficiency has three components: technical, allocative and economic. Technical efficiency is defined as the ability to achieve a higher level of output, given similar levels of inputs. Allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost. Technical and allocative efficiencies are components of economic efficiency. It is possible for a firm to exhibit either technical or allocative efficiency without having economic efficiency. Technical and allocative efficiencies are therefore together necessary conditions for economic efficiency.

Production functions have traditionally been used to examine efficiency of farmers in Africa. Examples of work along this line are Moock (1976) for Kenya, Bindlish and Evenson (1993) for Kenya, and Savadogo et al. (1994) for Burkina Faso. A production function approach, however, fails to capture inefficiencies associated with different factor endowments and different input and output prices across farms. Under such conditions, the farms may exhibit different "best-practice" production functions, and operate at different optimal points. Lau and Yotopoulos (1971) and Yotopoulos and Lau (1973) therefore popularized the use of the profit function approach, in which farm-specific prices and levels of fixed factors are incorporated in the analysis of efficiency. The advantage of using this approach is that input and output prices are treated as exogenous to farm household decision making, and they can be used to explain input use. The resulting parameter estimates will in general be statistically consistent. In the profit function approach, profit efficiency can be defined as the ability of a firm to achieve potential maximum profit, given the level of fixed factors and prices faced by the firm. Adesina and Djato (1996) recently applied this methodology in a study of efficiency of rice farmers in Cote d'Ivoire.

Aigner et al. (1977), however, showed that profit function models do not provide a numerical measure of firm-specific efficiency and popularized the use of the translog production frontier approach. The stochastic frontier approach has gained popularity in firm-specific efficiency studies. Examples of recent applications include Ali and Flinn (1989), Kumbhakar and Bhattarcharya (1992) and Ali et al. (1994). Profit inefficiency in this framework is defined as profit loss from not operating on the profit frontier, taking into consideration farm-specific prices and fixed factors.

The Stochastic Profit Frontier

Consider a firm that maximizes profits subject to perfectly competitive input and output markets and a single-output technology that is quasi-concave in the (n x 1) vector of variable inputs, X, and the (m x 1) vector of fixed factors, Z. The actual normalized profit function which is assumed to be "well-behaved"[1] can be expressed as

$$\pi(p,Z) = Y(X^*,Z) - \sum_i p_i \, X_i^*, \qquad\qquad X^* = g(p,Z) \qquad (1)$$

where $Y(\cdot)$ is the production function; the asterisk denotes optimized values; $p_i = W/P$, where P and W are the output and input prices, respectively, and p_i is the normalized price of input i. The stochastic profit function can then be expressed as

$$\pi_j = f(p_{ij}, z_{kj}) \cdot \exp e_j \qquad (2)$$

where Π_j is normalized profit of the jth farm, computed as gross revenue less variable cost, divided by farm specific output price P; p_{ij} is the normalized price of input i for the jth farm, calculated as input price divided by by farm specific output price P; z_{kj} is the level of the kth fixed factor for the jth farm; and e_j is an error term. The error term, e_j, is assumed to behave in a manner consistent with the frontier concept:

$$e_j = V_j + U_j \qquad (3)$$

where V_j is the symmetric error term and U_j is a one-sided error term. The V_js are assumed to be independently and identically distributed (i.i.d.) as $N(0, \sigma^2_v)$. We assume that U_j has a half-normal nonnegative distribution, $N(0, \sigma^2_u)$. U and V are also assumed to be independent of each other. U_j is used to represent inefficiency. That is, it represents profit shortfall from its maximum possible value given by the stochastic frontier. Thus, if $U_j = 0$, the firm lies on the profit frontier, obtaining

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[1] This implies the profit function is nonincreasing in input prices and nondecreasing in output prices, homogenous of degree zero in input and output prices and convex in input and output prices.

potential maximum profit given the prices it faces and the levels of fixed factors. If $U_j > 0$, the firm

is inefficient and loses profit as a result of inefficiency. An average frontier model results if the

frontier model is estimated without the one-sided disturbance term, U_j. This approach has been

criticized by Farrell (1957). On the other hand, a full deterministic or full frontier model, often

estimated by linear programming techniques, results if the random error term V_j is omitted. If

equation (2) is estimated econometrically rather than a model consisting of equations (2) and (3),

an average, as opposed to the frontier is obtained. It is therefore essential to estimate the frontier

function to provide an estimate of industry best-practice profit for any given level of prices and

fixed factors.

Given the specification of U, the population mean and variance of U, is (Maddala, 1973):

$$E(U) = \sigma_u \sqrt{(2/\psi)} \tag{4}$$

$$V(U) = \sigma_u^2 (\psi - 2)/\psi \tag{5}$$

where ψ is a constant equal to 3.14. The expected inefficiency in the population is then given as:

$$E\left(e^{-U}\right) = 2e^{\frac{\sigma_u^2}{2}} \left[1 - F(\sigma_U)\right] \tag{6}$$

where F is the standard normal distribution function.

Following Jondrow et al. (1982), the farm-specific representation of conditional

inefficiency $(U_j | e_j)$ for each observation is derived from the conditional distribution of U_j, where

$U_j = e_j + V_j$, and it has an expectation of:

$$E(U_j | e_j) = \frac{\sigma_u \sigma_v}{\sigma} \left[\frac{f(e_j \lambda/\sigma)}{1 - F(e_j \lambda/\sigma)} - \frac{e_j \lambda}{\sigma} \right] \tag{7}$$

where $\lambda = \sigma_u / \sigma_v$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and f and F are the standard normal density and cumulative distribution functions, respectively, evaluated at $e_j \lambda / \sigma$.

The farm-specific profit inefficiency index (PIE) derived using the results from equation (7) is given as:

$$PIE = (1 - \exp[-U_j]) \qquad (8)$$

Profit loss due to inefficiency is represented as potential maximum profit given farm-specific prices and fixed factors, multiplied by farm-specific profit inefficiency index. The second objective of the study is achieved by relating the profit inefficiency index to farm and household attributes. This can be specified as $PIE = g(X)$, where PIE is the profit inefficiency index and X is a vector of farm household attributes. The profit inefficiency index is therefore hypothesized to be related to attributes of the farm household.

Empirical Model

Flexible functional forms for the profit function include the normalized quadratic, normalized translog, and generalized Leontif.[2] In this study, we have chosen to use normalized translog stochastic profit function, assumed to be "well-behaved":[3]

$$\ln \Pi = \alpha_o + \sum_i \alpha_i \ln P_i + \frac{1}{2} \sum_i \sum_l \gamma_{il} \ln P_i \ln P_l +$$

$$\sum_i \sum_k \delta_{ik} \ln P_i \ln Z_k + \sum_k \beta_k \ln Z_k + \frac{1}{2} \sum_k \sum_h \phi_{kh} \ln Z_k \ln Z_h + V + U \qquad (9)$$

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[2] For example, Stefanou and Saxena (1988) employed a generalized Leontif specification for their study on allocative efficiency of Pennsylvania dairy farms, while Jayne et al. (1994) used a normalized quadratic in their productivity study on Zimbabwe.
[3] See footnote 1. Lopez (1985) shows, however, that the most flexible functional forms do not satisfy the properties of global monotonicity and convexity.

where i, $l = k$, $h = 1,2$ π is normalized profit computed as gross revenue less variable costs, divided by farm-specific rice price; P_1 is the money wage rate of labor per hour normalized by the price of rice; P_2 is the money price per kilogram of fertilizer nutrients normalized by the price of rice. Z_1 is the land input, measured as hectares of rice grown per farm; Z_2 is the capital input computed as the sum of costs of animal and mechanical power; ln is natural logarithm; V and U are the error terms defined in equation (3). The estimate of U_j is obtained by replacing e_j by its sample residual, and the unknown parameters given in equation (8).

The empirical measure of the profit inefficiency index, PIE_j* is obtained by inserting the sample residual for U_j in equation (8). The relationship between profit inefficiency and household attributes is specified as

$$PIE_j* = \alpha_0 + \alpha_1 CRED_j + \alpha_2 EDUC_j + \alpha_3 NFARM_j + \alpha_4 SPEC_j$$
$$+ \alpha_5 AGE_j + \alpha_6 DUM1_j + \alpha_7 DUM2_j + \alpha_8 DUM3_j + \varepsilon_j$$

where *CRED, EDUC, NFARM, SPEC,* and *AGE*, denote access to credit, level of head's education, head's nonfarm employment, level of specialization in rice, and age of the household head, respectively. *DUM1*, *DUM2*, and *DUM3* represent locational dummies, respectively, and ε is an error term.

Data and Empirical Definition of Variables

The data used for this empirical application are a subsample of a random sample of 256 farmers in four districts of Northern Ghana conducted in 1992-93. The farms in the sample are located in Tamale, Savelugu, Tolon and Gushiegu-Karaga districts. Information from these farm households were gathered through repeated visits using questionnaire. Additional survey data was

obtained from the Northern Region Ministry of Agriculture in Tamale. The data covered information on farm and nonfarm activities, as well as demographic and locational characteristics. Information on farm activities included fertilizer applications and prices, wages, capital assets, and livestock production. On cash-oriented nonfarm activities, information included weekly or monthly earnings and detailed individual time allocation.

The Northern Region presently accounts for more than half of total rice production in the country. Until irrigation projects gradually transformed the Accra-coastal plain into a major area of rice production, the region alone accounted for an average of 63% of rice production between 1977-1987. From the original 256 households in the survey, 120 farmers who cultivated rice—the most important cash crop grown in the area—were chosen from the four districts based on complete availability of needed information on the household. Table 1 describes selected characteristics of the sample farms. Output is measured in tons of paddy rice per hectare. The mean rice yield over the sampled farms was 1.5 tons per hectare of paddy rice, with a range of about 0.5 tons per hectare to 2.1 tons per hectare. The ″yield gap″ between the average and the lowest farm yield was 1.0 ton per hectare, and that between the average and the highest was 0.6 tons per hectare, suggesting that there is considerable room for improving average rice yields in the area.

Table 1

The input of land is measured as hectares of rice grown per farm in the year of the survey, total land cropped is measured as the total hectares that were under crop cultivation in that year. As in Sidhu and Baanante (1981), the total labor expenditure per farm includes the imputed costs of family labor at the wage rate paid to permanent hired labor. The money wage rate used in the

analysis is obtained by dividing the total labor expenditure for rice production per farm by the quantity of labor including both family and hired labor. Female and child labor is converted into man equivalents by treating two women (or children) equal to one man. Capital input is computed as the sum of costs of animal and mechanical power used in rice production. Price of fertilizer is measured as total expenditure on fertilizer per kilogram of fertilizer nutrients (including transportation and spreading cost). During the period under study, there were neither price support nor input subsidy schemes for rice farmers. Moreover, the imports of rice had been completely liberalized leaving production and distribution to the forces of supply and demand. The farm level observed prices show some variations which seems to be due to location and other things. Variation in the price of fertilizer seems to be due largely to location.

Variables representing farm and household characteristics employed in the analysis of the determinants of profit inefficiency include the level of specialization in rice production, hours of non-farm employment, and access to credit. Level of specialization in rice production is measured as the proportion of a farm's land area used in rice cultivation relative to total area that was under cultivation during the survey period. It is hypothesized that farmers that specialize in rice production would tend to devote more attention and resources meant for crop production to the rice sector than other producers, thereby gathering information, making decisions, and adopting technologies that increase efficiency.

The net effect of nonfarm work on efficiency is ambiguous, since participation in the nonfarm labor market may restrict production and decision making activities, thereby increasing inefficiency. On the other hand, increasing nonfarm work might reduce financial constraints, particularly for resource-poor farmers, enabling them to purchase productivity enhancing inputs

(Huffman, 1980). Access to formal credit may permit a farmer to enhance conventional allocative efficiency by overcoming financial constraints to the purchase of, say, fertilizer or a new technological package such as high yielding seeds. Credit could therefore increase the net revenue obtained from fixed inputs, market conditions and individual characteristics. A credit constraint may therefore increase inefficiency of farmers by limiting the adoption of high yielding varieties and the acquisition of information relevant for increasing productivity (Wozniak, 1993). Credit may have no effects on production, if it simply displaces another source of finance such as savings. It could even have negative impacts on profits if it is treated as a welfare program, perhaps because default costs are perceived as minor (Binswanger and Deininger, 1997). In the present study, individuals who indicated a desire for credit to purchase farm inputs, but could not obtain it are classified as credit constrained. For example, Weisssman (1990) reports that credit shortages in the study area adversely affected small farmers' access to inputs and cooperative storage facilities.

Two variables representing characteristics of the household head, age and education (number of years of schooling), are included in the analysis of the determinants of profit inefficiency. The simplifying assumption is that the household head, whether male or female, is also the primary decision maker on the family farm. Education, which represents human capital of the household head is generally postulated to have a positive impact on efficiency (Lockheed, Jamison, and Lau (1980). This common view of the role of human capital in production stems from the fact that reallocation of resources in response to changes in economic conditions requires (i) perceiving that change has occurred, (ii) collecting, retrieving, and analyzing useful information, (iii) drawing valid conclusions from the available information, and (iv) acting quickly

and decisively. This human ability to perceive changes in economic conditions and to respond efficiently is commonly referred to as allocative ability (Huffman, 1974, 1997). Allocative skill is (human) capital in the sense that it is acquired at a cost and tends to yield a valuable stream of services over future periods. It is acquired in schooling, by searching for information, and in experience from reallocating resources.[4]

District level dummies are also included to capture the impacts of locational characteristics on inefficiency. Factors that might contribute to relatively higher efficiency in certain districts may include (i) easier access to information, because of the location of extension services,   improved seed multiplication units, agricultural financial institutions, and fertilizer depots in the more accessible districts; (ii) better health and water facilities; and (iii) greater market access for their products. Farmers in such districts might therefore be more exposed to a "modernizing environment" where new crop varieties, innovative planting methods, and capital inputs such as insecticides and tractors or machines are readily available. In particular, Schultz (1975) has argued that education is likely to be more effective under modernizing conditions.

Results and Discussions

In this section, the results of the estimates of parameters of the stochastic translog profit function, the profit inefficiency measure, and the estimates of the parameters of the model relating the index of profit inefficiency to farmers' and households' attributes are presented and discussed.

Translog profit frontier results

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[4] The simplifying assumption of perfect information and rationality in the neoclassical economic theory preclude allocative ability from being a valuable skill to farms and households.

Maximum-likelihood estimates for the parameters of the normalized translog profit function subject to restrictions of homogeneity and symmetry are given in Table 2. The equation was estimated by LIMDEP version 7, developed by Greene (1995). The coefficients of the prices for fertilizer and labor have the expected negative signs, while those for land and capital are positive as expected. Lambda (λ), which is the ratio of the standard errors of U and V is 2.19, implying that the one sided error term U dominates the symmetric error V. This result indicates that variation in actual profit from maximum profit (frontier profit) between farms mainly arose from differences in farmer practices rather than random variability. The average measure of inefficiency [sample counterpart to equation (4)] is 27.4%, which suggests that on average, about 27% of potential maximum profit is lost due to inefficiency. This discrepancy between observed profit and the frontier profit is due to both technical and allocative inefficiencies.

Table 2

The frequency distribution of the farm specific profit inefficiency is reported in Table 3. The table shows that sample farm profit inefficiency varies widely. The maximum and minimum levels are 95.5 and 0.16%, respectively, with over 57% of sample farms exhibiting a profit loss of 20% or more as a result of inefficiency. The mean profit loss was 38,555 cedis per hectare. The largest sample farm profit loss was 134,380 cedis per hectare. Hence, our empirical measure of farm inefficiency are sizable and vary across farms

Table 3

Determinants of profit Inefficiency

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The parameter estimates of the relationship between profit inefficiency obtained from the stochastic frontier model and farm and household characteristics using ordinary least squares estimator are presented in table 4. The Breusch-Pagan test was employed to test for for potential heteroskedasticity, given the large variation in the level of specialization in rice production. The computed χ^2 value (18.92) was above the critical value (15.5) at the 5% level with 8 degrees of freedom, suggesting the presence of heteroskedasticity. In order to account for the heterosdasticity, the standard errors reported are calculated from White's (1980) formula that accounts for nonparametric forms of heteroskedasticity. The joint hypothesis that all non-intercept coefficients in the model are zero is rejected. The sample value of the Wald statistic is 19.78, and the critical value of χ^2_8 at the 5 percent significance level is 15.5.

Table 4

The results show that the level of education (human capital) of the household head tends to have highly significant impacts on profit inefficiency. The negative sign indicates that higher levels of education reduces inefficiency, a finding that is consistent with the review of Lockheed, Jamison, and Lau (1980). It is also in line with the findings of other studies such as Huffman (1974) for the United States, Ali and Flinn (1989) for Pakistan, and Kumbhakar and Bhattarcharya (1992) for India. The positive and significant coefficient of the non-farm employment variable indicates that farmers engaged in non-farm activities tend to exhibit higher levels of inefficiency. This finding is consistent with the results reported by Ali et al. (1994). The positive relationship suggests that increases in non-farm work are accompanied by a reallocation of time away from

farm-related activities such as adoption of new technologies and gathering of technical information that is essential for enhancing production efficiency (Wozniak, 1993).

A negative and statistically significant relationship is also found between access to credit and profit inefficiency, suggesting that farmers lacking credit to purchase fertilizer or engage additional labor tend to experience higher profit inefficiency. Older farm operators seem to be less efficient than the younger ones. This suggests that negative effects of finite life weighs more heavily than positive experience effects. With finite life, young farmers have more years to obtain benefits from making costly change, and this is an additional reason why older farmers have lower adoption rates for profitable technologies or seem to be more inefficient.

Farmers located in the Tamale, Savelugu and Tolon districts appear to exhibit higher efficiencies relative to farmers in the Gishiegu-Karaga area, although a statistically significant coefficient was obtained only for farmers in the Tamale district. The mean level of profit inefficiency for farmers in the Tamale district was 24.6% compared to 30% for farmers in the Gushiegu area. These imply mean per hectare losses of 34,699 cedis and 42,213 cedis, respectively. The joint hypothesis that all coefficients of the district dummies are zero was rejected. The sample value of the Wald statistic is 9.46 while the critical value ((χ^2_3) is 7.81. This is not surprising because the regional extension services and fertilizer depots are located in the Tamale district, enabling farmers in the district to have better access to extension services and agricultural information than those in other districts. This finding lends support to Schultz's hypothesis that the effectiveness of education on efficiency is enhanced in a modernizing environment.

Conclusions and Policy Implications

This paper employs a stochastic translog profit frontier model to examine production efficiency among rice farmers in the Northern Region of Ghana. The estimates of the translog profit frontier indicate that inputs are still important to profitability of rice farming in Ghana. Efficiency measures indicate that rice farmers are not applying their inputs in an absolutely efficient way. The average inefficiency is 27.4% with a wide variation (maximum of 95.5% and minimum of 0.16%), suggesting that considerable amount of profit is lost due to inefficiency.

The findings from the inefficiency analysis suggest that higher head's education, access to credit and greater specialization, as well as location in districts where extension services and better infrastructure are available, are significant variables for increasing profit efficiency. Increasing participation in nonfarm activities by farmers and being older, however, tend to lower profit efficiency. These findings have important policy implications in promoting efficiency among farmers in Ghana and Africa in general. In particular, the significance of the education variable implies that perceiving and responding efficiently to changes in economic conditions require allocative ability that is acquired by investing in education and useful information. This conforms to Mellor's (1976) argument that investment in education in rural areas should be considered as a central ingredient in a strategy to improve agricultural productivity, principally through its complementarity with new inputs such as chemical fertilizers and pesticides, and effective research and extension services. Investments in rural education in the currently changing political and economic environment in Ghana will provide farmers with skills essential in increasing efficiency.

The finding of the relationship between inefficiency and access to credit also suggest that improving access of farmers to institutional credit will improve production efficiency. Consequently, improving efficiency of resources will require streamlining the acquisition of credit

among small farmers. However, allocating public expenditure to urban areas or large farmers who are politically vocal does not help the rural poor gain access to credit. It rather undermines their ability to operate as family farmers, therefore increasing inequality, and also reduces efficiency and long-run growth. Specialization as measured by the share of total cultivated land devoted to rice production also tends to lower inefficiency, indicating that channeling relatively scarce resources (e.g., labor and capital) into rice production will improve efficiency.

The results of the locational dummies also suggest that policy makers need to consider improving the access of farmers located in remote areas to extension services and agricultural information. As shown empirically by Lockheed, Jamison, and Lau (1980), the effects of education in a modernizing environment — availability of capital inputs such fertilizers and machines, and exposure to extension services — are substantially greater than under traditional conditions.

Compared to previous studies on African agricultural productivity, our results generally show that employing the stochastic profit frontier model allows a detailed analysis of the determinants of specific-farm inefficiency. Further work is, however, required to capture the effects of farm-specific soil conditions and environmental factors when examining farm-specific efficiencies.

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Table 1. Selected Characteristics of the Sample Farms in Northern Region of Ghana, During 1992-93.

Farm and Household characteristics	Definition	Minimum	Mean	Maximum
Total farm area	Total land cultivated in hectares	0.8	4.1	27.8
Household size	No of persons in household	3	8.4	14
Head's age	Age of household head	20	39.2	54
Education level	Years of schooling of head	0	3.66	12
Nonfarm employment	Hours spent on nonfarm work per year	0	541.9	1760
Credit constraint	Dummy: 1 if head is credit constraint		0.38	
Tamale	Dummy: 1 if live in Tamale district		0.24	
Savelugu	Dummy: 1 if live in Savelugu district		0.24	
Tolon	Dummy: 1 if live in Tolon district		0.25	
Rice Production				
Farm size	Area in hectares	0.7	3.2	19.6
Fertilizer use	Nutrient kg per hectare	90	180	240
Yield	Tons per hectare	0.5	1.5	2.1
Paddy price*	Cedis per 100 kg	13,800	14,500	15,100
Labor	Days per hectare	116	198	214
Wage rate*	Cedis per hour	43	57	72

*The reigning exchange rate was about 400 Cedis to a US dollar

Table 2. Maximum Likelihood Estimates of Translog Profit Frontier

Variable	Parameter	Coefficient	Standard Errors
Constant	α_0	4.7642	1.6303
ln $p1$ (fertilizer)	α_1	-0.6918	0.2281
ln $p2$ (labor)	α_2	-0.1952	0.1393
ln $p1$ x ln $p1$	α_{11}	0.1021	0.2424
ln $p2$ x ln $p2$	α_{22}	0.1003	0.2889
ln $p1$ x ln $p2$	α_{12}	-0.2367	0.8835
ln $z1$ (land)	β_1	0.6131	0.2417
ln $z2$ (capital)	β_2	0.2327	0.1149
ln $z1$ x ln $z1$	β_{11}	0.2057	0.5571
ln $z2$ x ln $z2$	β_{22}	0.2040	0.0742
ln $z1$ x ln $z2$	β_{12}	0.4095	0.1033
ln $p1$ x ln $z1$	γ_{11}	-0.5692	0.1438
ln $p1$ x ln $z2$	γ_{12}	0.0997	0.3549
ln $p2$ x ln $z1$	γ_{21}	0.9391	0.8967
ln $p2$ x ln $z2$	γ_{22}	0.3579	0.2020
Lambda (σ_u / σ_v)	λ	2.1970	0.4400
Sigma	σ	0.4656	0.0748
	σ^2_u	0.1796	
	σ^2_v	0.0372	
Log-likelihood		-320.117	

Table 3. Frequency Distribution of Farm Specific Profit Inefficiencies in Stochastic Translog Profit Frontiers

Inefficiency Index (%)	Number of Farmers	Percentage	Inefficiency Index (%)	Number of Farmers	Percentage
0–1	3	2.5	50–55	5	4
1–3	6	5	55–60	2	1.7
3–5	11	9	60–70	3	2.5
5–7	8	7.5	70–75	3	2.5
7–9	5	4	75–79	4	3.3
9–14	7	5.8	80–95	3	2.5
14–20	13	10.8			
20–25	13	10.8			
25–30	8	7.5	Mean	27.4	
31–35	10	8.3	STD	22.6	
35–40	6	5	Min	0.16	
41–45	3	2.5	Max	95.5	
45–50	8	7.5			

Table 4. Relationship of Profit Inefficiency with Farm and Household Characteristics

Variable	Coefficient	Standard Error
Constant	0.2584***	0.0483
Non-farm Employment	0.3664***	0.1238
Education	-0.5732***	0.1225
Credit Availability	-0.6061***	0.0952
Age	0.1136*	0.0631
Rice Share of Total Area	-0.1800***	0.0386
Tamale	-0.0337**	0.0134
Savelugu	-0.0199	0.0135
Tolon	-0.0076	0.0129
Adjusted R^2	0.647	
Breusch-Pagan χ^2	18.92	
Wald $\chi^2(8)$	19.78	

Standard errors are calculated from White's formula that accounts for nonparametric forms of heteroskedasticity. ***, ** and * are significant at 1% , 5% and 10% level of significance.