African Crop Science Journal, Vol. 15, No. 4, pp. 243 - 253
ISSN 1021-9730/2007 $4.00

ANALYSIS OF PROFIT INEFFICIENCY IN RICE PRODUCTION IN EASTERN AND NORTHERN UGANDA

T.S. HYUHA, B. BASHAASHA, E. NKONYA[1] and D. KRAYBILL[2]
Department of Agricultural Economics and Agribusiness, Faculty of Agriculture, Makerere University, P.O. Box 7062, Kampala, Uganda
[1]International Food Policy Research Institute (IFPRI), Washington, D.C. USA.
[2]Department of Agricultural Environmental & Development Economics, Ohio State University, Columbus Ohio, U.S.A

ABSTRACT

Rice is among the emerging crops in Uganda that play an important role both as a food and a cash crop. It ranks fourth among the cereal crops in area cultivated, occupying a total of 80 thousand hectares of land with an estimated annual output of 120,000 metric tonnes. The study analyses sources of technical and allocative inefficiency and estimates the magnitude of profit losses and suggests policy interventions. A stochastic profit function and inefficiency function are estimated using cross-sectional data from a sample of 253 households from three districts of Eastern and Northern Uganda. The results show that rice farmers are not operating on the profit frontier. The main causes of inefficiency are firm-specific which include low education and limited access to extension services. These two factors have hampered the attainment of reasonable technical and allocative efficiency. From these results, it is clear that improvement in profit efficiency would require focused programmes to increase access to education and extension services.

Key Words: Allocative inefficiency, profit function, stochastic profit function

RÉSUMÉ

Le riz est parmi les récoltes émergentes en Ouganda. Il joue un rôle important de nourriture et une récolte génératrice d'argent. Il est classé quatrième parmi les récoltes de céréale dans le secteur cultivé, occupant un total de 80 milles hectares de terre avec une production annuelle estimée de 120.000 tonnes métriques. L'étude analyse des sources d'inefficacité des techniques et dans l'allocation et estime la grandeur de pertes de profit et suggère les interventions dans la réglementation. Une fonction de profit stochastique et la fonction d'inefficacité sont estimés en utilisant des données d'une coupe de section longitudinale d'un échantillon de 253 ménages de trois quartiers de d'est et le nord d'Ouganda. Les résultats montrent que les cultivateurs de riz ne fonctionnent pas sur la frontière de profit. Les causes principales d'inefficacité sont fermes spécifiques qui inclut le bas niveau de l'éducation et l'accès limité aux services d'extension. Ces deux facteurs ont entravé la réalisation de technique raisonnable et d'allocation efficace. De ces résultats, c'est clair que l'amélioration dans l'efficacité de profit exigerait que les programmes soient focalisés sur l'augmentation de l'accès aux services d'éducation et de vulgarisation.

Mots Cles: Allocation ineffective, fonction de profit, fonction stochastique de profit

INTRODUCTION

Rice is among the emerging staple and commercial crops grown in Uganda (Sabiiti, 1995; Ochollah *et al*., 1997). Over a decade ago, rice ranked first in returns per labour among the major crops grown in the country (APC, 1997; Jagwe *et al.*, 2005). On the other hand, with an estimated annual output of 120,000 tonnes, the crop ranks fourth among the cereal crops in area in the country (UBOS, 2004). Although the crop is increasingly becoming a staple in the country, especially in urban areas; however, available statistics show that Uganda is a net importer of rice (Table 1) and will continue to do so unless domestic production improves significantly (World Bank, 1993; Hyuha, 2006). This is feasible since the country offers ideal conditions for rice production (Chinese Rice Study, 1982).

Despite its uncontestable growing importance of rice in Uganda, the crop ranks low in terms of research priorities among the cereal crops within the National Agricultural Research Organization (NARO). It is only recently that the crop has attracted the attention of agricultural research (Cereal Programme Leader, Namulonge Agricultural and Animal Production Research Institute, 1998, personal communication). Even then the emphasis is barely on upland rice, particularly the new rice for Africa-NERICA. NERICA's potential yield in sub-Saharan Africa is 5 metric tonnes per hectare, with use of fertilizers, but on farmers' field in Uganda it is just 2.2 metric tonnes (WARDA, 2001).

The above figures depict a big potential for increased output; however, the biggest challenge is limited knowledge on the causes of this gap. This study, therefore, aimed at analysing the sources of inefficiency in rice production and estimating the magnitude of profit loss due to allocative and technical inefficiency so as to fill the identified gap.

METHODOLOGY

Study sites and procedure. This study was conducted in Uganda, in 2001 in three districts, namely, Tororo, Pallisa and Lira. Tororo and Pallisa are located in Eastern Uganda, whereas Lira is located in Northern Uganda. The three districts were selected mainly because of their high ranking in rice production in the country. In fact for the period 1993-2000 they accounted for 67% of the national rice production (Uganda Bureau of Statistics, 2004; 2005).

The registers of participating rice farmers constituted a sampling frame in Tororo and Lira. However, in Pallisa District, since there was no official register for small-scale farmers, the assistance of agricultural officials was enlisted to identify major rice growing sub-counties. Once the villages were identified, a village register was used to draw the required sample. Where this did not exist, the village chairman (local administrator) was consulted and a fresh register was compiled.

A structured questionnaire was then used to collect primary quantitative data from a sample of 297 households, of which 253 were used in the analysis. The rest were dropped because they did not contain all the information required to estimate the translog model. The 253 observations were distributed as follows: Tororo (138); Pallisa (104) and Lira (55). Tests for departure from normality in the data were conducted.

The stochastic profit frontier function (Equation 4), and the inefficiency function

TABLE 1. Uganda annual rice exports and imports in tonnes, 1990-2004

Year	Exports	Imports	Net imports
1990-1995	565	5,136	4,571
1996	260	19,150	18,890
1997	2,680	48,960	46,280
1998	2,080	81,340	79,260
1999	350	59,760	77,140
2000	2,350	77,590	75,240
2001	1,340	33,850	32,510
2002	1,210	64,690	63,480
2003	1,430	72,710	71,280
2004	12,150	83,720	71,570

Source: FAOSTAT, 2008

(Equation 5) were estimated using the FRONTIER 4.1 computer package (Coelli, 1996). The programme combines the two-stage procedure into one and produces maximum likelihood estimates of the parameters of a stochastic profit frontier function. This procedure is superior to two-stage procedures because it does not violate the assumption that the inefficiency effects are independently and identically distributed (Battesse and Coelli, 1995; Coelli, 1995; Coelli, 1996; Abdulai and Huffman, 2000; Rahman, 2002).

Theoretical considerations and empirical model. Measurement of economic efficiency has become a common place in the literature on efficiency, especially after the pioneering work of Farrell (Farrell, 1957). Farrell provided a framework for the computation of a production frontier. However, it was not until the work of Aigner and Chu (1968) that the frontier function was first explicitly specified in a parametric form. Afriat (1972) used a one-sided error term in which observed variations were said to be endogenous, while weather, wars and droughts were treated as random factors. Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) employed the concept of a stochastic frontier in which a two sided random error term was introduced explicitly in a production function as follows:

$$Y = f(x, \beta)\, \ell^{\nu-\mu} \quad \text{...(1)}$$

Where ν represents a symmetric disturbance term assumed to be identically and independently distributed (i.i.d.) as N (0, σ^2) and is one-sided half normal with a distribution of N (0, σ^2_i), and also i.i.d. If ó^2_i is zero, the function is deterministic; and if greater than 0, it is stochastic. Efficiency measurement is estimated separately by estimating technical and allocative efficiency from a production frontier. However, this may fail to capture inefficiencies associated with different factor endowments and input and output prices across farms (Abdulai and Huffman, 2000). This is due to the fact that farmers face different endowments and different optimal operating points. Lau and Yotopolous (1971) had earlier suggested incorporation of firm specific prices and fixed factors as arguments in estimating the model to make it firm specific. This helps to transform a production function into a profit function.

The profit function, unlike the production approach, combines both technical and allocative concepts in a profit relationship, and any errors in production decisions are translated into lower revenue for the producer (Ali *et al.*, 1994) and, hence, lower profit efficiency. The profit function approach has received limited application in contrast to the production function approach in developing countries (Ali *et al*., 1994; Rahmann, 2002). It has the advantage of avoiding the simultaneity bias that typically occurs in the estimation of production functions (Saleem, 1988).

The more recent developments in modelling farm specific profit function efficiency, have overcome the earlier criticism on its suitability in less developed countries. Sevilla-Siero (1991) argues that one does not need the assumptions of competitive input and output markets to hold in order to define a farm's profit function, or to use a profit approach to measure efficiency. What is required is for all the output and input prices to be exogenous to the farm. Moreover, as demonstrated by Wang *et al*. (1996) and Fan (1999), this approach has been used successfully in countries such as China where distortions were explicit.

The translog frontier profit function model adopted in this study has the following form:

$$Y_j = \quad (P_j, Z_j)\, exp(e_j) \quad \text{....................................... (2)}$$

where Y_j is normalised profit of the jth farm defined as gross revenue less variable cost divided by farm-specific commodity prices. P_j is a vector of variable input prices for the jth farm computed as input prices divided by farm-specific output price. Z_j is a vector of fixed factor inputs, and e_j is an error term:

$$e_j = \nu_j - \mu_j \quad \text{... (3)}$$

where and μ_j are as defined before except that the error term μ_j measures profit inefficiency and ν_j measures random factors. When $\mu_j = 0$, the firm is obtaining the maximum profit and operating on the frontier given the prices and fixed factors. If $\mu_j > 0$ the firm is economically inefficient and the profit is less than the maximum.

The firm-specific inefficiency effects are obtained by referring to the distribution of the μ_j term in Equation 3, which are non-negative random variables assumed to be i.i.d. such that μ_j is defined by truncation at zero of the normal

distribution with a mean of
and variance σ^2_μ, where
w_d is the d^{th} explanatory variable representing socio-economic characteristics of farm j and δ_o and δ_d are both unknown parameters to be estimated.

This study estimates a flexible translog profit function (equation 4) and inefficiency function (Equation 5):[1]

$$\ln \pi' = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln p_i + \tfrac{1}{2} \sum_{i=1}^{3} \sum_{k=1}^{3} r_{ik} \ln p_i \ln p_k + \sum_{i=1}^{3}\sum_{l=1}^{2} \phi_{il} \ln p_i \ln z_l + \sum_{l=1}^{2} \beta_l \ln z_l + \tfrac{1}{2} \sum_{l=1}^{2}\sum_{q=1}^{2} \varphi_{lq} \ln z_l \ln z_q + v - \mu \quad \text{.................. (4)}$$

Where $\mu = \delta_0 + \sum_{d=1}^{6} \delta_d w_d + \vartheta$ .... (5)

$r_{ik} = r_{ki}$ For all k, i

π'	=	restricted normalized profit computed for the farm defined as gross revenue less variable costs divided by farm specific rice price (p_j)
p_i (p_j)	=	price of variable inputs (i, k =1, 2, and 3) normalised by price of output
p_1	=	the cost of hired labour normalised by price of rice (p_j)
p_2	=	the cost of non-labour inputs normalised by price of rice (p_j)
p_3	=	imputed cost of family labour normalised by the price of rice (p_j)
Z_ι	=	the quantity of fixed input (ι = 1, 2)
Z_1	=	land under rice (hectares under rice) in farm j
Z_2	=	capital used in farm j
μ	=	inefficiency effects
ϑ	=	truncated random variable
δ_0	=	constant in equation 5
w_d	=	6 variables explaining inefficiency effects, defined as follows:
w_1	=	non-farm employment (indeterminate)
w_2	=	education level of household head (negative sign)
w_3	=	access to extension services (negative sign)
w_4	=	access to credit (negative sign)
w_5	=	experience in rice production (negative sign)
w_6	=	degree of specialisation (negative sign)

α_0, α_i, r_{ik}, $ø_{il}$, β_l, φ_{lq}, δ_0 and w_d are parameters to be estimated.

jth
$\mu_j = \delta_o +$

Education level of household head, access to extension services in terms of number of visits by extension agent, access to credit, farmer's experience in rice production and degree of specialisation in rice production are hypothesised to carry a negative sign in the inefficiency model, implying that they enhance efficiency.

Education is expected to improve the quality of labour; however, the impact depends on the environment. For instance, in a rapidly changing technological or economic environment, the impact of education is higher (Schultz, 1975).

A pertinent question to ask is: whose education matters to agricultural productivity? Appleton and Balihuta (1996) used a variable representing education of the household while Weir (1999) used an education variable representing the community.

Access to extension services is a conduit for the diffusion of new technologies to the farmer; hence, it is expected to reduce inefficiency in

[1] *The model is adopted from Rahman (2003) with some modifications.*

production. Indeed, a number of studies (Ali and Byerlee, 1991; Seyoum *et al*., 1998; Rahman, 2002, 2003) confirmed this. As with extension, credit is a catalyst to the use of improved technology, which in turn should lead to a reduction in profit inefficiency. Ali and Flinn (1989) and Abdulai and Huffman (2000) reported a negative influence for credit among rice farmers in Pakistani and Northern Ghana, respectively. Experience should also enhance proficiency. Indeed, studies by Wilson *et al*. (1998) and Rahman (2002) show that farmers who have more years in the enterprise achieved higher levels of efficiency. This is in line with classical economic theory which recognizes that specialisation is a key determinant of efficiency.

Non-farm employment was included to capture access to extra income, which can then be used to purchase agricultural input to improve productivity. Rahman (2002) included this variable to capture the unemployment situation in Bangladesh. However, engaging in non-farm employment could deprive the farm of valuable time to perform farming operations in a timely manner. Therefore, non-farm employment could lead to an increase in inefficiency (Rahman, 2002, 2003; Abdulai and Huffman, 2000; Ali and Flinn, 1989). Because non-farm employment could exert either a negative or positive influence on inefficiency, we do not predict its effect.

RESULTS AND DISCUSSION

A log likelihood test revealed that the Cobb-Douglas formulation is not an adequate representation of rice production. We then proceeded to estimate a frontier translog model (Equations 4 and 5) although we concentrated on the results of the inefficiency equation in the following sections.

Socio-demographic characteristics. Table 2 shows socio-demographic characteristics of the households studied in the three districts. Generally, the respondents were in similar age categories, with a mean of 41 years for Tororo and Lira, and 40 for Pallisa. Tororo district has the largest household size of 9 compared to 8 for both Pallisa and Lira districts. This slightly larger size could be explained by a slightly bigger number of children (6) compared to the other districts (5) and extended families. The size could also be attributed to the high population growth rate.

The mean land holdings for the three districts were 1.77, 2.88 and 2.02 hectares for Tororo, Pallisa and Lira, respectively. Out of this, 70% was under crop cultivation in Tororo and Pallisa districts, and 58% in Lira. The low level of crop cultivation in Lira district could be explained by lack of oxen, which used to be the major mode of cultivation before the ongoing civil unrest in the region. Lira,

TABLE 2. Selected socio-economic characteristics of rice farmers in eastern and northern Uganda

Characteristics	Tororo	Pallisa	Lira
Age household head (years)	41.09(1.2)	40.02(1.39)	41.2(1.43)
Household size	9.37(0.47)	8.41(0.49)	8.36(0.66)
Number of children	6.42(0.35)	5.36(0.31)	5.40(0.37)
Land (ha)	1.77(0.13)	2.88(0.34)	2.02(0.20)
Crop (ha)	1.25(0.08)	2.14(0.20)	1.17(0.10)
Rice (ha)	0.57(0.04)	0.72(0.09)	0.21(0.00)
Experience (years)	15.51(0.75)	13.5(0.91)	6.27(2.80)
Number of plots	1.68(0.07)	1.28(0.004)	1.14(0.32)
n	138	104	55

Figures in brackets are standard deviations the newest entrant into rice production among the three study districts, had the smallest area (0.21 ha) of rice cultivated per farmer. In contrast, the area cultivated was 0.57 ha in Tororo and 0.72 ha in Pallisa.

Generally, each district had more than one plot of rice per household, though Tororo had the highest (1.68 ha) and Lira the lowest (1.14 ha). This was expected because Tororo is one of the districts that benefited from the initial government's policy of promoting rice production in the country. This is also reflected in experience levels, whereby farmers in Tororo had the highest number of years (16) in rice production, followed by Pallisa (14 years) and lastly by Lira (6 years).

Table 3 shows descriptive statistics for other variables studied. Tororo district had the lowest level of education, with 51% of the respondents having attended primary education, compared to Pallisa, which had 68%. Access to formal credit by rice farmers was only 44%, which was evidently poor. This is not unique to rice as a crop because Yilma (1996) also found that coffee producers in Masaka district had poor access to credit. In fact, the informal access to loans predominated with a value of 77.4%. This may be because these sources are easily accessible with minimum transaction costs and conditions, even though the interest rate can go as high as 50% per year. Access to extension services is also limited; a paltry 21% of the farmers had access extension services. Furthermore, there is limited opportunity for earnings from non-farm sources, as only 27% respondents were engaged in non-farm employment activities. Pallisa district seemed to have the best opportunities (31%), followed by Tororo (28%) and Lira (18%).

Determinants of farm-specific inefficiency in rice production. Model estimates based on Equation 5 are presented in Table 4. As expected, non-farm employment was negative and statistically significant in Pallisa and Lira districts. This implies that having access to non-farm employment enhances efficiency in rice production in the two districts. Non-farm employment presumably generates earnings that allow farmers to hire labour and purchase inputs. In Tororo, however, non-farm employment is positive but not significant. On the other hand, it

TABLE 3. Other household characteristics of rice farmers in eastern and northern Uganda

Variables	Tororo	Pallisa	Lira	Average
Education				
None	21.7	10.6	16.4	16.8
Primary	50.7	68.8	60.0	58.6
Sec/Tertiary	27.5	21.0	23.7	24.6
Credit access				
Yes	35.5	48.1	56.4	43.8
No	64.5	51.9	43.6	56.2
Source				
Formal	14.3	2.0	22.6	22.6
Informal	85.7	98.0	77.4	77.4
Extension services				
Yes	17.4	8.9	52.7	20.9
No	82.6	91.3	47.3	79.1
Non-farm employment				
Yes	28.3	30.8	18.2	27.3
No	71.7	69.2	81.8	72.7
N	138	104	55	297

TABLE 4. Determinants of farm-specific inefficiency in rice production in eastern and northern Uganda.

Parameter	Pooled		Tororo		Pallisa		Lira	
	Coeff	p-v[1]	Coeff	p-v[1]	Coeff	p-v[1]	Coeff	p-v[1]
Constant (w_0)	2.09	0.00	3.84	0.00	3.51	0.00	2.28	0.00
Non-farm employment (w_1)	0.37	0.01	0.06	0.89	-0.95	0.03	-0.93	0.00
Education (w_2)	-0.14	0.00	-0.25	0.00	-0.16	0.00	-0.30	0.00
Extension services(w_3)	-0.16	0.00	-0.26	0.00	-0.47	0.00	-0.28	0.03
Credit access(w_4)	-0.25	0.15	-0.55	0.05	-0.46	0.03	-0.24	0.44
Experience (w_5)	-0.07	0.67	-0.44	0.17	-0.49	0.00	0.06	0.78
Degree of specialisation(w_6)	-0.08	0.00	-0.14	0.00	-0.15	0.00	-0.03	0.17

[1]P-values (p-v) are computed from t-ratios; Dependent variable = inefficiency (μ)

was significant in the pooled data. Our mixed results are not surprising as previous studies also failed to agree on the effect of non-farm employment on inefficiency. For instance, Abdulai and Huffman (2000) found that having access to non-farm employment enhanced efficiency of rice farmers in Northern Ghana. The same conclusion was reached earlier by Ali and Flinn (1989) for rice farmers in Pakistan, as was the case in China (Wang *et al*., 1996) and Bangladesh (Rahman (2002 and 2003). For tobacco production in Uganda, however, Obwona (2006) found that non-farm employment had no effect.

Results for the education and access to extension services variables were negative and statistically significant in all the districts and for the pooled data. This indicated consistent enhancement of efficiency in rice production. Our results are consistent with those of several other researchers (Ali and Flinn, 1989; Ali and Byerlee, 1991; Bravo-Ureta and Rieger, 1991; Wang *et al*., 1996; Seyoum *et al*., 1998; Abdulai and Huffman, 2000; Rahman, 2002; Obwona, 2006). Thus, programmes to encourage those of school-going age are expected to raise productivity in rice farming. Similarly, improving access to extension services for rice farmers, in particular, would be beneficial in reducing inefficiency in rice production.

Access to credit is expected to ease the financial constraint in farming; enhance the acquisition of input and, improve revenue and, subsequently, profits. Indeed, the results for Tororo and Pallisa districts show that access to credit reduces inefficiency in rice profits. Coefficients on the credit variable for Lira district and for the pooled data carry the expected sign although they were not significant (P>0.1).

Whereas the coefficients associated with experience in rice production carried the expected negative sign in the pooled data for Tororo and Pallisa, they were significant only in the latter. Our results provide only weak evidence that experience reduces inefficiency, while many previous studies find strong evidence of this relationship (Ali and Byerlee, 1991; Sharma *et al.*, 1999; Abdulai and Huffman, 2000; Rahman, 2002; Kolawole, 2006).

Constraints to profit efficiency in rice production by district. Results for key factors contributing to profit loss by district are presented in Tables 5 through 7. Profit loss is considered here as the difference between maximum profit and actual

TABLE 5. Profit loss in rice production in Tororo district by constraint

Variables	n	Actual profit 000's Shs	Profit loss 000's Shs	Efficiency scores
Educational level				
None	24	968.6 [a](3.8)[1]	524[a](3.7)	45.9 [a](2.5)
Primary	61	962.6 [a](2.3)	489[b](2.3)	49.2 [b](1.6)
Secondary	33	953.5 [b](3.2)	451 [c](3.2)	52.7[c](2.1)
Tertiary	5	637.0 [c](10.6)	286[d](8.1)	50.1 [d](5.5)
Credit access				
Yes	43	1104.0[a]	467 [a]	57.7 [a]
No	80	1069.5[b]	523 [b]	51.1 [b]
Extension services				
Yes	22	1114.4[a]	487 [a]	56.3 a
No	101	1118.1[b]	549 [b]	50.9 [b]
Degree of specialisation				
0-25%	34	815.4[a](17.6)	515.5[a](2.7)	59.1 [a](0.5)
25.1-50%	55	1081.4 [b](20.4)	514.8[a](3.5)	57.4 [a](0.9)
50.1+	34	1281.4 [c](17.6)	507.1[b](5.5)	55.3[b](1.2)

[1]Across the categories of each variable, different superscripts along columns depict significant differences at p<0.10 level Similar subscripts imply that the differences are not significant. Values in brackets are standard errors

TABLE 6. Profit loss in rice production in Pallisa District by constraint

Variables	n	Actual profit 000's Shs	Profit loss 000's Shs	Efficiency scores
Educational level				
None	8	672.4[a](7.4)[1]	351 [a] (6.3)	47.8 [a] (1.5)
Primary	64	659.5[b](2.2)	337 [b] (2.2)	48.9 [a] (0.5)
Secondary	17	574.6 [c](4.6)	281[c](4.3)	51.1 [b] (1.1)
Tertiary	2	523.5[d](29.2)	245 [d](12.6)	53.2 [a] (3.1)
Credit access				
Yes	41	615.6[a]	269 [a]	56.3 [a]
No	50	586.8[b]	338 [b]	42.4 [b]
Extension services				
Yes	8	711.9 [a]	294 [a]	58.7 [a]
No	83	645.8[b]	361[b]	44.1 [b]
Degree of specialisation				
0-25%	36	1091.3[a](17.6)	513.9[a](4.1)	57.9[a](0.9)
25.1-50%	33	1137.8[a](20.4)	508.2[b](4.7)	57.1[a](1.2)
50.1+	22	924.8[b](18.5)	499.8[c](6.9)	55.1[b](1.5)

[1]Across the categories of each variable, different superscripts along columns depict significant differences at P<0.10 level Similar subscripts imply that the differences are not significant. Figures [in] brackets are standard errors

TABLE 7. Profit loss in rice production in Lira District by constraint

Variables	n	Actual profit 000's Shs	Profit loss 000's Shs	Efficiency scores
Educational level				
None	8	199.1[a](4.9)[1]	131 [a](2.4)	34.2 (1.7)
Primary	23	237.3[b](2.6)	126 [b] (1.4)	46.9 [b] (1.0)
Secondary	6	191.3 [a] (6.1)	97 [c](2.8)	49.3 [c b](2.0)
Tertiary	2	153.7[c](20.0)	71 [d](4.9)	53.8 [c d](3.4)
Credit access				
Yes	21	155.0 [a]	73 [a]	52.9[a]
No	18	307.5[b]	155 [b]	49.6 [b]
Extension services				
Yes	20	174.7 [a]	87 [a]	50.2[a]
No	19	323.8 [b]	169 [b]	47.8 [b]
Degree of specialisation				
0-25%	15	1151[a]	510 [a]	59.4[a]
25.1-50%	17	1056[a]	514[a]	58.2[a]
50.1+	7	975.5[b]	521[a]	57.6[b]

[1]Across the categories of each variable, different superscripts along columns depict significant differences at P<0.10 level. Similar subscripts imply that the differences are not significant. Figures in brackets are standard errors

profit given prices and fixed factor endowments. For farmers who did not go to school, profit loss per hectare was significant, and ranged from Ushs 131,000 in Lira (Table 7) to Ushs 524,000 in Tororo (Table 5). In the four categories ranging from no education to tertiary education, higher levels of education were associated with smaller profit losses in each of the three districts and the differences among the categories were significant at the 10% level. Education also translated into efficiency gains. For example, in Lira district, farmers who had no education were only 34% efficient, while those with education had the following efficiency levels: primary (47%), secondary (49%), and tertiary (54%).

Access to credit reduced profit loss in all three districts. For farmers with access to credit, profit losses ranged from Ushs 73,000 per hectare in Lira district, to Ushs 467,000 per hectare in Tororo district. These findings suggest that having access to credit improves profit efficiency from 51 to 58% in Tororo district, 42 to 56% in Pallisa district, and from 50 to 53% in Lira district.

Access to extension services also reduced profit losses in all three districts. Generally, farmers receiving extension services experienced efficiency improvements of 5% points, from 51 to 56% in Tororo, 15 % points from 44 to 59% in Pallisa, and two percentage points from 48 to 50% in Lira.

CONCLUSIONS

This study has revealed that rice farmers in Eastern and northern Uganda do not operate on the profit frontier. Major causes of inefficiency across the three districts are low levels of education and limited access to extension services. Farmers with no education experienced the highest loss of profit per hectare as compared to those with education. Access to extension services enhances profitability, and those who did not have access experienced greater profit loss per hectare. Another factor reducing efficiency is limited access to credit. There is, therefore need for education for all rice farming communities. The universal primary education policy implemented in the country in 1997 is a step in the right direction. Furthermore, more resources should be devoted to rice extension services. Lastly, access to credit should also receive the necessary attention.

REFERENCES

Abdulai, A. and Huffman, W. 2000. Structural adjustment and economic efficiency of Rice Farmers in Northern Ghana. *Economic Development and Cultural Change* 504-519.

Afriat, S.N. 1972. Efficiency estimation of production function. *International Economic Review* 13:568-598.

Agricultural Policy Committee APC.1997. Report on Economics of Crops and Livestock Production , Agricultural Policy Secretariat, Ministry of Planning and Economic Development.

Aigner, D.J. and Chu, S.F. 1968. On estimating the industry production function. *American Economic Review.* 58:826-839.

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

Ali, M. and Byerlee, D. 1991. Economic efficiency of small farmers in a changing world: A survey of recent evidence. *Journal of International Development* l3 (1):1-27.

Ali, M. and Flinn, J. 1989. Profit efficiency among basimati rice producers in Pakistan Punjab. *American Journal of Agricultural Economics* 71(2):303-310.

Ali, F. Parikh, A. and Sha , M.K. 1994. Measurement of profit efficiency using behavioral and stochastic frontier approaches. *Applied Economic* 26: 181-188.

Appleton, S. and Balihuta, A. 1996. Education and agricultural productivity: evidence from Uganda. *Journal of International Development* 8: 415-445.

Battese, G.E and Coelli, T.J. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20: 325-332.

Bravo-Ureta, B.E. and Rieger, L. 1991. Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. *American Journal of Agricultural Economics Review.* 22(1): 88-101.

Chinese Rice Study Team of the Peoples Republic of China, 1982. The feasibility for rice irrigation in Uganda, October 1982. A Report written for the Republic of Uganda.

Coelli, T. J. 1995. Recent development in frontier modeling and efficiency measurement. *Australian Journal of Agricultural Economics* 39: 219-245.

Coelli, T.J. 1996. A guide to frontier version 4.1:A computer programme for stochastic frontier production and cost function estimation mimeo, Department of Econometrics, University of New England, Armidale.

Jagwe, J. Okoboi G. Arayo, E. and Abele, S. 2005. Market Opportunity identification study for 5 selected key crops in Kabarorle district, Western Uganda. CRS-Food net Uganda. A Report to Catholic Diocese of Fort Portal Development Bureau, Uganda.

Fan, S. 1999. Technological change, technical and allocative efficiency in Chinese Agriculture: The case of rice production in Jiangsu. (EPTD Discussion Paper no 39, International Food Policy Research Institute IFPRI).Washington, D.C.

Farrell, M. J. 1957. The measurement of productivity efficiency. *Journal of Royal Statistical Society Series* 120: 253-290.

Food and Agricultural Organization statistics. 2008 http:faostat.org

Hyuha, T. 2006 Profit efficiency among rice producers in Eastern and Northern Uganda. Unpublished PhD Thesis. Makerere University.

Kolawole, O. 2006. Determinants of profit efficiency among small-scale rice farmers in Nigeria: a profit function approach. Poster Paper presented at Internationalisational Association of Agricultural Economist Conference, Gold Coast, Australia, August 12-18, 2006 http://ageconsearch.umn.edu/bitstream/123456789/1036/1/pp060688.pdf Accessed on 25th February 2008.

Lau, I.J. and Yotopolous, P.A. 1971. A test for a relative and application to Indian agriculture. *American Economic Review* 61: 94-109.

Meeusen, W. and Van den Broeck, J. 1977. Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review* 18: 435-44.

Obwona, M.2006. Determinants of technical efficiency differentials amongst small-and medium-scale farmers in Uganda: A case of tobacco growers. African Economic Research Consortium Research Paper 152.

Ochollah, A.R. Ogenga–Latigo, M.W. and. Nsubuga, E.N.B 1997. Impact of upland rice cultivation on crop choice and income of farmers in Gulu and Bundibugyo districts. *African Crop Science Proceedings* 3: 1407-1411.

Rahman. S. 2002. Profit efficiency among Bangladesh rice farmers Manchester: University of Manchester. (School of economic studies. discussion paper series No. 0203).

Rahman. S. 2003. Profit efficiency among Bangladeshi rice farmers. *Food Policy* 28: 483-503.

Sabiiti, A.G. 1995. An economic analysis of production of cow pea in Northern and Eastern Uganda. Unpublished master's thesis, Makerere University, Kampala, Uganda.

Saleem, S. T. 1988. Relative efficiency of cotton farms in Sudanese irrigated agriculture *World Development* 16(8): 975-984.

Seyoum, E.T. Battese, G.E. and Fleming, E.M. 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* 19: 341-348.

Sharma, K. R. PingSun, L. and Halina M. Z. 1999. Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches. *Agricultural Economics* 20: 23-35.

Schultz, T.W. 1975. The Value of Ability to deal with disequilibria. *Journal of Economic Literature* 13: 827-846.

Sevilla-Siero, C. A. 1991. On the use and misuse of profit functions measuring the price responsiveness of peasant farmers: A comment. *The Journal of Development Studies* 27(4): 123-136.

Uganda Bureau of Statistics, 2004. Statistical Abstract. Ministry of Finance, Planning and Economic Development.

Uganda Bureau of Statistics, 2005. The 2002 Uganda Population Housing Census, main Report The Republic of Uganda.

WARDA, 2001. New rice for Africa(NERICA) offers hope to Women farmers and millions more. Abidjan, Ivory Coast. http://www.warda.org/main/Achivements/nerica.htm

Wang, J. Cramer, G. L. and Wailes, E. J.1996. Production efficiency of Chinese agriculture: Evidence from rural household survey data. *Agricultural Economics* 15: 17-28.

Weir, S 1999 The effects of education on farm productivity in rural Ethiopia (WPS99-7). Oxford: University Oxford, Department of Economics, Centre of African Economics.

Wilson, P. Hadley D., Ramsden, S. and Kaltsas, I, 1998. Measuring and explaining technical efficiency in UK potato production. Journal of Agricultural Economics 49(3):293-305.

World Bank, 1993. Growing out of Poverty: A World Bank Country Study (Uganda). World Bank , Washington D.C.

Yilma, M. 1996. Measuring smallholder efficiency: Uganda coffee and food crop production. Unpublished dissertation, Gotborgs Universitent:Ekonomiska Studier Utgivna av Nationalekomiska Institionen Handelsh, Kompeniet-Goteborg, Sweden.