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SOURCE OF TECHNICAL EFFICIENCY AMONG SMALL HOLDER MAIZE AND PEANUT FARMERS IN THE SLASH AND BURN AGRICULTURE ZONE OF CAMEROON

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Measures of technical efficiency were conducted with 450 farmers in the slash and burn zone in Cameroon. Stochastic production frontier functions were used to compute farm-level technical efficiency (TE). The analysis reveals that the average level of technical efficiency equals to 78%, 80% and 77%, respectively, for the groundnut monocrop, maize monocrop and maize/groundnut intercrop systems. It also appears that the TE are invariant across cropping practices. The results suggest that substantial gains in output and/or in cost decrease can be attained by improving present technical practices. In a second step analysis a two-limit tobit regression technique was used to examine the relationship between TE and various farm/farmer characteristics. The results show that schooling and membership to farmer's club or association are variables most promising for action. The analysis suggests that policymakers should foster the development of the formal farm's club or association by building the capacity of the farmers on creation and management skills. The analysis also support that the public sector involvement in the provision of information and technical assistance to farmers as a means to improve technical efficiency levels and household income is necessary.

1. INTRODUCTION

Agriculture is an important sector in the Cameroonian economy. Recent studies show that it accounted for as much as 30% of the gross domestic product (GDP), 70% of overall employment, and over 40% of total foreign exchange earnings (DSCN, 2002).

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A significant feature of agriculture in the slash and burn zone of Cameroon is the dual structure of the farming system, composed of farming practices that produce perennial export crops (coffee, cocao, bananas, oil-palm), and small peasants farms that produce annual foods for subsistence and local markets. For both systems, the productivity is low.

The poor performance of the forest zone agriculture is evidenced by the low standard of living in rural areas compared to cities; thus, the largest concentration of absolute poverty, illiteracy and infant mortality is found in the countryside (DSCN, 2002).

There is general agreement that a sustainable economic development depends on promoting productivity and output growth in the agricultural sector, particularly among small-scale producers. Empirical evidence suggests that small farms are desirable not only because they reduce unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Pinheiro, 1993, 1997). Consequently, many researchers and policymakers have focused their attention on the impact the adoption of new technologies can have on increasing farm productivity and income (Hayami and Ruttan, 1985; Kuznets, 1966). However, during the last decade, major technological gains stemming from the green revolution have been effective across the developing world. This suggests that attention to productivity gains arising from a more efficient use of existing technology is justified (Bravo-Ureta and Pinheiro, 1993, 1997; Squires and Tabor, 1991).

The presence of shortfalls in efficiency means that output can be increased without requiring additional conventional inputs and without the need for new technologies. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving performance in production with a given technology. Policy implication stemming from significant levels of inefficiency is that it might be more cost effective to achieve short-run increases in farm output, and thus income, by concentrating on improving efficiency rather than introducing new technologies (Belbase and Grabowski, 1985; Shapiro and Müller, 1977).

In the slash and burn agriculture zone of Cameroon, groundnut and maize are the second and third most important food crops after cassava.

They are planted either in monocrop or in association. Improving the technical efficiency (TE) of these crop-based systems will contribute enormously to improving the overall agricultural productivity in the slash and burn zone of Cameroon.

From 2000 to 2003, the European Union-funded project financially supported not only the introduction of improved groundnut and maize varieties in the slash and burn zone of Cameroon, but it also supported the study of the technical efficiency of these crop-based systems.

The objective of this study is to assess the possibilities of productivity gains by improving the efficiency of groundnut and maize-based systems used by farmers in the slash and burn agriculture zone of Cameroon, by estimating a stochastic production frontier which provides the basis for measuring farm-level technical efficiency (TE) and by separating the two-limit tobit equation for TE estimation as a function of various attributes of the farms/farmers in the sample. The study has policy implications because it not only provides empirical measures of technical efficiency indices, but also identifies key variables that are correlated with these indices. The analysis performed this way goes beyond much of the published literature concerning efficiency because much research in this area of productivity analysis focuses exclusively on the measurement of technical efficiency (Bravo-Ureta and Pinheiro, 1993; Coelli, 1995).

1.1. Existing Empirical Studies in Africa

The literature on productive or technical efficiency in African agriculture is emerging, but the technical efficiency of Cameroonian agriculture has not been adequately studied despite decades of policy efforts in improving the agricultural productivity of the economy. Globally, there is a wide body of empirical research on the economic efficiency of farmers both in the developed and developing countries (Bravo-Ureta and Pinheiro, 1993; Battese, 1992 and Coelli, 1995). While the empirical literature on the efficiency of farmers is vast in developing countries and Asian economies, few studies focus on African agriculture. Udry et al. (1995), using detailed plot-level agronomic data from Burkina Faso, found that the value of household output could be increased by 10-15% by reallocating currently used factors of production across plots. Heshmati and Mulugeta (1996) estimated the technical efficiency of Uganda's matoke-producing farms and found that the matoke-producing farms face technologies with decreasing returns to scale with mean technical efficiency of 65 percent, but found no significant variation in technical efficiency with respect to farm sizes. This study, however, does not identify the various sources of technical efficiency among matoke-producing farmers.

Seyoum et al. (1998) investigated the technical efficiency and productivity of maize producers in Ethiopia and compared the performance of farmers within and outside the programme of technology demonstration. Using Cobb-Douglas stochastic functions, their empirical results show that farmers that participate in the programme are more technically efficient with mean technical efficiency equal to 94 percent compared with those outside the project with mean efficiency equal to 79 percent. Townsend et al. (1998), using data envelopment analysis, investigated the relationship between farm size, return to scale and productivity among wine producers in South Africa and found that most farmers operate under constant returns to scale, but the inverse relationship between farm size and productivity is weak.

Weir (1999) investigated the effects of education on farmer productivity of cereal crops in rural Ethiopia using average and stochastic production functions. This study finds substantial internal benefits of schooling for farmer productivity in terms of efficiency gains but finds a threshold effect that implies that at least four years of schooling are required to lead to significant effects on farm level technical efficiency. Using different specifications, average technical efficiencies range between 44 and 56 per cent, and rising education from zero to four years in the household leads to a 15 per cent increase in technical efficiency. Moreover, the study finds evidence that average schooling in the village (external benefits of schooling) improves technical efficiency. Nyemeck (1999), using stochastic production function, investigated the relationship between some farms/farmer characteristics among cereal crop producers in rural Cameroon. This study finds that technical efficiency ranges between 76 and 78 per cent, and that the schooling effects on technical effiency are mixed in terms of efficiency gains but also finds that the gender of the head of the household affects technical efficiency. Clearly, the study finds that farms managed by men are more likely to improve technical efficiency than those managed by women.

Weir and Knight (2000) analysed the impact of education externalities on production and technical efficiency of farmers in rural Ethiopia, and found evidence that the source of externalities to schooling is in the adoption and spread of innovations which shift out the production frontier. Mean technical efficiencies of cereal crop farmers are 55 percent and a unit increase in years of schooling boosts technical efficiency by 2.1 percentage points. Nonetheless, one limitation of the Weir (1999) and Weir and Knight (2000) study is that they only investigated the levels of schooling as the only source of technical efficiency.

Mochebelele and Winter-Nelson (2000) investigated the impact of labour migration on the technical efficiency performance of farms in the rural economy of Lesotho. Using the stochastic production function (translog and Cobb-Douglas), the study found that households that send migrant labour to South Africa mines are more efficient than households that do not send migrant labour with mean efficiencies of 36 and 24 per cent, respectively. In addition, there is not statistical evidence that the size of the farm or the gender of the household head affects the efficiency of farmers. Mochebelele and Winter-Nelson (2000) conclude that remittances facilitate agricultural production, rather than substitute for it. This study does not consider many other household characteristics that may affect technical efficiency such as education, farmers' experience, access to credit facilities (capital), advisory services and social capital.

2. METHODOLOGY

2.1. Data and Study Area

During the 2001-2002 growing season, 450 farmers were visited and interviewed in the oil-palm, short fallow and cocoa, long fallow zones of Makak, Nkometou and Ebolowa, respectively. This data set was considered sufficient to conduct technical efficiency analysis and to run the tobit equation.

The systems chosen for the analysis are maize monocrop, groundnut monocrop and maize/groundnut intercrop. These three systems are used by 72% of the farmers in the slash and burn zone. In some areas such as Nkometou and other villages close to the cities, these three systems are practiced by 87% of farmers.

2.2. Empirical Model

Despite its well known limitations, we use a Cobb-Douglas functional form to specify the stochastic production frontier. In fact, Taylor et al. (1986) argued that as long as interest rests on efficiency measurement and not on the analysis of the general structure of the production technology, the Cobb-Douglas production function provides an adequate representation of the production technology. Moreover, in one of the very few studies examining the impact of functional form on efficiency, Kopp and Smith (1980) concluded "…that functional specification has a discernible but rather small impact on estimated efficiency". That is why the Cobb-Douglas functional form has been widely used in farm efficiency analyses both in developing and developed countries (Battese, 1992; Bravo-Ureta and Pinheiro 1993). The specific model estimated is given by:

$$\ln Y = \ln A + \sum_{i=1}^{3} \beta_i \ln X_i + \varepsilon_i \qquad (1)$$

where A and β_I are parameters to be estimated ($i = 1, \ldots 3$), Y is output and the X_i are inputs and ε_i is defined as above. A more detailed definition of these variables is given below.

The output variable in equation (1), Y, is the production level obtained of groundnut or maize measured in kg. The variable X_1 includes the cultivated land, multiplied by a soil fertility index[1] (Kalirajan and Shand 2001; Rahman, 2003), X_2 includes family and hired labour measured in man-day, X_3 corresponds to the capital used (total expenditures on seeds and small farm tools for the year) measured in CFA francs. The explanatory variables included in this model have been commonly used in estimating agricultural production frontiers for developing countries (Kalirajan and Flinn, 1985; Phillips and Marbes, 1986; Taylor et al., 1986; Bravo-Ureta and Pinheiro, 1997; Nyemeck, et al., 2003) and particularly in the slash and burn agriculture zone of Cameroon (Adesina et al., 2000; Nkamleu and Adesina, 2000).

[1] The soil fertility index is constructed from test results of soil samples collected from the study villages during the field survey. Eight soil fertility parameters were tested. These are: soil pH, available nitrogen, available potassium, available phosphorus, available sulphur, available zinc, soil texture, and soil organic matter content. A high index value refers to better soil fertility.

The essential idea behind the stochastic frontier model is that ε is a "composed error" term (Aigner, Lovell, and Schmidt, 1977; Meeusen and Van Den Broeck, 1977). This term can be written as:

$$\varepsilon = v - u \qquad (2)$$

where v is a two-side ($-\infty < v < \infty$) normally distributed random error ($v \sim N[0, \sigma_v^2]$) that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise. The term u is a one-side ($u \geq 0$) efficiency component that captures the technical inefficiency of the farmer. This one-side term can follow such distributions as half-normal, exponential, and gamma (Aigner, Lovell, and Schmidt, 1977; Greene, 1980; Meeusen and Van Den Broeck, 1977). In this paper, it is assumed that u follows a half-normal distribution ($u \sim |0, \sigma_u^2|$) as typically done in the applied stochastic frontier literature. The two components u and v are also assumed to be independent of each other.

The maximum likelihood estimation of equation (1) yields consistent estimators for A, β, σ^2, and γ, where $\beta, \sigma^2 = \sigma_v^2 + \sigma_u^2, \gamma = \frac{\sigma_u^2}{\sigma^2}$ are estimated. Jondrow et al. (1982) have shown that inferences about the technical efficiency of individual farmers can be made by considering the conditional distribution of u given the fitted values of ε, and the respective parameters. In other words, given the distribution assumed for v and u, and assuming that these two components are independent of each other, according to Battese and Corra (1977), the farm-specific estimates of technical efficiency are defined by:

$$TE_i = E\left\{\exp(-u_i / \varepsilon_i)\right\} = \frac{1 - \Phi\left[\sigma_{u_i}^* + \gamma\varepsilon_i / \sigma_{u_i}^*\right]}{1 - \Phi\left[\gamma\varepsilon_i / \sigma_{u_i}^*\right]} \exp(\gamma\varepsilon_i + \frac{1}{2}\sigma_{u_i}^{*\,2}) \qquad (3)$$

where Φ is the cumulative function of the standard normal variable, $\sigma_{u_i}^* = \sqrt{\gamma(1-\gamma)\sigma_\varepsilon^2}$ is an estimated parameter of the conditional distribution u_i / ε_i. The mean technical efficiency of all farms in a system is given by:

$$TE = \left\{ \frac{1 - \Phi[\sigma + (\mu/\sigma)]}{1 - \Phi(\mu/\sigma)} \right\} \exp\left(\mu + \frac{1}{2}\sigma^2 \right) \qquad (4)$$

3. RESULTS AND DISCUSSION

3.1. The Stochastic Frontier Model Results

Based on the model discussed in the methodology section, Table 1 presents maximum likelihood (ML) estimates of the stochastic production frontier. Results found in this study are similar to the findings of the production frontier literature (Bravo-Ureta and Evenson, 1994). Moreover, all parameter estimates are statistically significant at the 1 percent level for the three models.

TABLE 1: MAXIMUM LIKELIHOOD (ML) PARAMETER ESTIMATES

		Models		
		Groundnut	Groundnut/ Maize	Maize
Independent		Monocrop	Mix	Monocrop
Variable	Coefficient	N = 150	N = 150	N = 150
Intercept	β_0	4.6^{***} (10.13)	5.9^{***} (33.4)	4.1^{***} (11.6)
$\ln X_1$	β_1	0.40^{***} (3.6)	0.44^{***} (7.7)	0.12^{***} (21.8)
$\ln X_2$	β_2	0.31^{***} (2.8)	0.29^{***} (9.8)	0.45^{***} (10.2)
$\ln X_3$	β_3	0.32^{***} (3.7)	0.24^{***} (5.04)	0.40^{***} (6.5)
	σ^2	0.21^{**} (2.7)	0.22^{***} (5.001)	0.42^{***} (5.9)
	γ	0.88^{**} (-2.13)	0.99^{**} (-2.32)	0.99^{**} (-2.27)
	$\chi^2_{(1)}$	3.98	13.38	6.3

$^{**}p<0.05$, $^{***}P<0.01$

Furthermore, a set of hypothesis that there are no technical inefficiency effects in the models was tested. The null hypothesis that $\gamma = 0$ is rejected at the 5% level of significance in all cases confirming that inefficiency exists and is indeed stochastic (LR statistics 3.98, 13.38, and 6.3 > $\chi^2_{(1,0.95)}$ = 2.71[2])

[2] See Coelli et al., (1998).

The estimated values of γ are 0.88, 0.99 and 0.99, which means respectively that 88% and 99% of the total variation in farms output is due to technical inefficiency in the different cropping systems.

The results also indicate that technical efficiency (TE) indices range from 51 to 94% for the groundnut monocrop system, with an average of 78% (Table 2). This indicates that if the average farmer in the sample was to achieve the TE level of its most efficient counterpart, then the average farmer could realise 17% cost savings (i.e. 1-[78/94]).

TABLE 2: FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY

Efficiency (%)	Cropping Systems		
	Mono groundnut	Inter groundnut/maize	Mono maize
	Frequency (%)	Frequency (%)	Frequency (%)
ϕ 95	0	14	14
ϕ 90 ≤ 95	6	3	13
ϕ 85 ≤ 90	6	13	6
ϕ 80 ≤ 85	23	6	6
ϕ 75 ≤ 80	27	16	13
ϕ 70 ≤ 75	13	13	13
ϕ 65 ≤ 70	16	13	10
ϕ 60 ≤ 65	3	6	10
ϕ 55 ≤ 60	3	6	6
ϕ 50 ≤ 55	3	10	9
ϕ 45 ≤ 50	0	0	0
ϕ 40 ≤ 45	0	0	0
ϕ 35 ≤ 40	0	0	0
ϕ 30 ≤ 35	0	0	0
ϕ 25 ≤ 30	0	0	0
≤ 25	0	0	0
Mean (%)	78	77	80
C. V (%)	13	18	20
Minimum (%)	51	52	53
Maximum (%)	94	99	99

A similar calculation for the most technically inefficient farmer reveals cost savings of 46 % (i.e. 1-[51/94]). Table 2 also shows that TE ranges from 52 to 99% and 53 to 99% respectively for maize/groundnut intercrop and maize monocrop systems, with an average of 77 and 80%. This means that if the average farmer in inter cropping system was to achieve the TE level of its most efficient counterpart, then the average farmer could realise a 22% cost savings (i.e. 1-[77/99]). The same cropping system reveals cost savings of 48% for the most technically inefficient farmer.

A similar calculation indicates that if the average farmer in the maize monocrop system was to achieve the TE level of its most efficient counterpart in the sample, then the average farmer could realise a 19% cost savings. Moreover, the most technically inefficient farmer in that cropping system could realise a 47% cost savings.

TABLE 3: ANOVA TEST OF TE INDICES ACROSS DIFFERENT CROPPING SYSTEMS

Test	Distribution	Computed value	Critique value 5%	Null hypothesis H_0 ([a])
BARTLETT	$\chi^2_{(2)}$	5.43	5.99	Accepted
ANOVA	$F_{(2,447)}$	0.32	3.11	Accepted

([a]): $H_0 : \sigma_1^2 = \sigma_2^2 = \sigma_3^2$ for BARTLETT test H_0: $TE_1 = TE_2 = TE_3$ for ANOVA test.

No significant differences were found between the means of TE indices among cropping systems (Table 3). This means that TE indices are independent of the cropping practices in humid and forest zone in Cameroon.

As existing empirical studies in Africa show that 77, 78 and 80 per cent means of technical efficiency found in this study are in line with the finding reported by others.

For policy purposes, the identification of factors influencing efficiency has also been an important exercise but the debate as to whether the single or two-stage method is appropriate is not yet settled. Battese and Coelli (1995) and Kumbakar (1994) challenge the two-stage approach by arguing that the farm-specific factors should instead be incorporated directly in the first stage estimation of the stochastic frontier because such factors can have a direct impact on efficiency and they propose a model incorporating these variables. Nevertheless, the two-stage method is mostly preferred due to a round-about effect of variable on efficiency (Kalirajan, 1991; Bravo-Ureta and Rieger, 1991; Bravo-Ureta and Evenson, 1994; Bravo-Ureta and Pinheiro, 1997; Sharma et al., 1999).

To delve deeper into this matter, and based on the literature, the following models investigating the relationship between farm/farmer characteristics and the predicted TE indices were estimated:

$$Effic = f(EDUC, AGE, SIZE, PEOP, CLUB) \quad (5)$$

Where *Effic* is, alternatively, the farm-level TE of different cropping systems. All variables in equation *(5)*, with exception of *PEOP* are dummy variables and are defined in Table 4 below.

TABLE 4: DESCRIPTION OF SOCIO-ECONOMIC AND CULTURAL VARIABLES USED FOR THE TWO-LIMIT TOBIT REGRESSION

Variable	Description of the variable	Values
EDUC	Dummy variable representing the average education level of the farmer	1 = the farmer has four or more years of schooling; 0 = otherwise
AGE	Dummy variable representing the age of the farmer	1 = younger farmers (those less than 25 years of age); 0= otherwise
PEOP	Family size	Number of the people in the household including the household head
CLUB	Dummy variable representing membership to a farmer's club or association	1= yes; 0 = no
SIZE	Dummy variable representing land size	1 = medium size (which are those of 0.5 and 2 hectares); 0= otherwise

The variables included in equation *(5)* are those usually incorporated in an analysis of this type (Belbase and Grabowski, 1985; Kalirajan and Flinn, 1985; Squires and Tabor; Bravo-Ureta and Pinheiro, 1997; Nyemeck et al, 2003).

The models for TE in equation (5) are estimated separately using the two-limit tobit model procedure, given that the efficiency indices are bounded between 0 and 1 (Greene, 1991; Hossain, 1988).

The two-limit tobit model is written as follows:

$$Effic_i^* = \beta' X_i + u_i$$

where $Effic_i^*$ is the latent value of efficiency scores. If we denote by *Effic* the observed value of efficiency scores:

$$\begin{aligned} Effic_i &= L_{1i} \text{ if } Effic_i \leq L_{1i} \\ &= Effic_i^* \text{ if } L_{1i} \; \pi \; Effic_i^* \; \pi \; L_{2i} \quad (6) \\ &= L_{2i} \text{ if } Effic_i^* \geq L_{2i} \end{aligned}$$

where L_{1i} et L_{2i} are, respectively, the lower and the upper limits: that means 0 and 1. The X_i are the determinants of efficiency defined in (5).

The maximum likelihood estimation of equation (6) yields consistent estimators for $\hat{\beta}$, where $\hat{\beta}$ is a vector of unknown parameters. The maximum likelihood function is showed as follows:

$$L(\beta,\sigma|y_i,x_i,L_{1i},L_{2i}) = \prod_{y_i=L_{1i}} \Phi\left(\frac{L_{1i}-\beta' x_i}{\sigma}\right) \prod_{y_i=y_i^*} \frac{1}{\sigma}\phi\left(\frac{y_i-\beta' x_i}{\sigma}\right) \prod_{y_i=L_{2i}} \left[1-\Phi\left(\frac{L_{2i}-\beta' x_i}{\sigma}\right)\right] \quad (7)$$

Where Φ and ϕ are respectively the normal standard cumulative and density function.

3.2. The Tobit Model Results

According to the results of the second step regressions, presented in Table 5, EDUC has a positive and highly significant impact on TE in mono cropping maize system, while the effect on TE in both mono cropping and inter cropping groundnut/maize systems is also positive but not significant. These results indicate that farmers with four or more years of schooling exhibited higher levels of TE. These results are similar to the findings of Weir (1999) and Weir and Knight (2000). Weir (1999) found substantial internal benefits of schooling for farmer productivity of cereal crops in rural Ethiopia in terms of efficiency gains but found a threshold effect that implies that at least four years of schooling are required to lead to significant effects on farm level technical efficiency. In Cameroon, the mono cropping and inter cropping groundnut/maize systems are specially practiced by women who are generally illiterate as compared to men farmers who have generally more than four years of schooling.

The results show also that farmers under twenty-five years of age have higher levels of TE. These results are consistent with the findings of Kalirajan and Flinn (1983) and Bravo-Ureta and Pinheiro (1997). According to Hussain (1989), older farmers are less likely to have contacts with advisory or extension agents and are less willing to adopt new practices and modern inputs. Furthermore, younger farmers are likely to have some formal education, and therefore might be more successful in gathering information and understanding new practices, which in turn will improve their TE.

TABLE 5: TWO-LIMIT TOBIT EQUATIONS FOR TECHNICAL EFFICIENCY OF CROPPING SYSTEMS IN SLASH AND BURN ZONE OF CAMEROON

Variables	Cropping systems					
	Mono peanut		Inter peanut-maize		Mono maize	
	Mean (S.D)	Parameter (S.E)	Mean (S.D)	Parameter (S.E)	Mean (S.D)	Parameter (S.E)
Intercept	-	0.724*** (0.138)	-	0.864*** (0.122)	-	0.721*** (0.121)
EDUC	0.40 (0.21)	0.001 (0.008)	0.46 (0.236)	0.009 (0.010)	0.700 (0.46)	0.017** (0.008)
AGE	0.387 (0.495)	0.037 (0.039)	0.555 (0.486)	0.104** (0.051)	0.658 (0.321)	0.036*** (0.012)
PEOP	9 (2)	0.008 (0.017)	6 (2)	-0.029 (0.031)	9 (3)	0.001 (0.018)
CLUB	0.524 (0.381)	0.130*** (0.031)	0.671 (0.376)	0.078*** (0.025)	0.69 (0.23)	0.226*** (0.064)
SIZE	0.952 (0.690)	-0.004 (0.061)	0.615 (0.344)	0.016 (0.131)	1.359 (1.025)	0.043 (0.052)

$^{**}p<0.05$, $^{***}P<0.01$

Communitarian social capital variable, measured as membership to a farmer’s club or association (CLUB) has a positive and statistically significant connection with TE. Of all the variables considered in the second step analysis, CLUB is the only one that has uniformly the same sign and is statistically significant in all three efficiency equations. This finding is consistent with Glover’s argument (1984) that club members farming can be very valuable for small-scale operations, because it facilitates access to markets and increases income and agricultural activities. In addition, club members production provides farmers with a secure market for their crops as well as some technical assistance which constitutes a source of farmer technical efficiency.

4. CONCLUSION AND POLICY RECOMMENDATIONS

This study presents measures of technical efficiency for a sample of 450 farmers in the slash and burn zone in Cameroon. Maximum likelihood techniques were used to estimate a Cobb-Douglas production frontier, which was used to derive farm-level technical efficiency measures.

The analysis reveals that the average levels of technical efficiency equal to 78, 80 and 77% respectively for groundnut monocrop, maize monocrop and maize/groundnut intercrop systems. These results suggest that substantial gains in output and/or decreases in cost can be attained given the existing technology. We would like to point out that despite the role that higher efficiency levels can have on output, productivity gains stemming from technological innovations remain of critical importance in agriculture. Hence, research efforts directed toward the generation of new technology should not be neglected.

In a second step analysis, the relationship between TE and various attributes of farms and farmers was examined. The second step analysis relied on two-limit tobit regression techniques to estimate three separate equations, where TE was expressed as function of five farm/farmer characteristics. The results show that younger, more educated farmers and membership to farmer's club or association exhibited higher levels of TE. This result pointed out the importance of social capital on productivity gains in slash and burn zone of Cameroon.

From a policy point of view, it should be noted that schooling and membership to a farmer's club or association are the variables most promising for action. Policymakers should therefore foster the development of the formal farm's club or association by building the capacity of the farmers on creation and management skills. It should also be pointed out that the public sector must be involved in the provision of information and technical assistance to farmers as a means to improve efficiency levels, and thus household incomes. This could be done via the farmer field school methods.

REFERENCES

Adesina, A.A., Mbilla, D., Nkamleu, G.B and Endamana, D., "Econometric Analysis of the Determinants of Adoption of Alley Farming by Farmers in the Forest Zone of Southwest Cameroon", *Agriculture Ecosystems & Environment 2000,* 1581:1-11.

Aigner, D.J., Lovell, C.K., and Schmidt, P., "Formulation and Estimation of Stochastic Frontier Production Function Models", *Journal of Econometrics,* 6 (1), 1977, pp. 21-37.

Battese, G.E., "Frontier Production Functions and Technical Efficiency: A Survey of Empirical Applications in Agricultural Economics", *Agricultural Economics,* 7 (3), 1992, 187-208.

Belbase, K., and Grabowski, R., “Technical Efficiency in Nepalese Agriculture”, *Journal of Development Areas,* 19 (4), 1985, 515-525.

Bravo-Ureta, B.E., and Evenson, R.E., “Efficiency in Agricultural Production: The Case of Peasant Farmers in Easten Paraguay”, *Agricultural Economics,* 10 (1), 1994, 27-37.

Bravo-Ureta, B.E., and Pinheiro, A.E., “Efficiency Analysis of Developing Country Agriculture: A Review of the Frontier Function Literature”, *Agricultural and Resource Economics Review*, 22 (1), 1993, 88-101.

Bravo-Ureta, B.E., et Reiger, L., “Alternative Production Frontier Methodologies and Dairy FARM Efficiency”, *Journal of Agricultural Economics,* 41 (2), 1990, 215-226.

Bravo-Ureta, BE. And Pinheiro, A.E., “Technical, Economic and Allocative Efficiency in Peasant Farming: Evidence from the Dominican Republic”, *The Developing Economics*, xxxv (1), 1997, 48-67.

Coelli, T.J., “Recent Development in Frontier Modelling and Efficiency measurement”; *Australian Journal of Agricultural Economics,* 39(3), 1995, 219-245.

Coelli, T.J., *A guide to FRONTIER Version 4.1: A Computer Program for Frontier Production Function Estimation,* CEPA Working Paper 96/07, Department of Econometrics, University of New England, Armidale, 1996.

Coelli, T., Prasada, R.D.S., and Battese, G., *Introduction to Efficiency and Productivity Analysis,* Boston, Kluver Academic Publisher, 1998.

DSCN. 2002, *Conditions de vie des populations et profil de pauvreté au Cameroun en 2001*: *Premiers résultats,* Direction de la Statistique et de la Comptabilité Nationale, Yaoundé-R.C., Mai 2002.

Greene, W.H., “Maximum Likelihood Estimation of Econometric Frontier Function”, *Journal of Econometrics,* 13 (1), 1980, 27-56.

Greene, W.H., *LIMDEP*: *User’s Manuel and Reference Guide*, New York: Econometric Software, Inc., 1991.

Hayami, Y. and Ruttan, W., *Agricultural Development: An international Perspective*, Baltimore, Md.: Johns Hopkins University Press, 1985.

Heshmati, A. and Mulugeta, Y., "Technical Efficiency of the Uganda Matoke Farms", *Applied Economic Letter,* 13, 1996, 27-57.

Hossain, Mahabub, *Nature and Impact of the Green Revolution in Bangladesh*, Washington D.C., Research Report 67, International Food Policy Research Institute, 1988.

Hussain, S.S., *Analysis of Economic Efficiency in Northen Pakistan: Estimation, Causes and Policy Implications*, Ph.D dissertation, University of Illinois, 1989.

Jondrow, J., Lovell, C.A., Materov, S., and Schmidt, P., "On Estimation of Technical Efficiency in the Stochastic Frontier Production Function Model", *Journal of Econometrics,* 19 (2/3), 1982, 233-238.

Kalirajan, K., "An Econometric Analysis of Yield Variability in Paddy Production", *Canadian Journal of Agricultural Economics,* 29 (3), 1981, 283-294.

Kalirajan, K. "Farm-Specific Technical Efficiencies and Development Policies", *Journal of Economic Studies,* 11 (3), 1984, 3-13.

Kalirajan, K., and Flinn, J.C., "The Measurement of Farm Specific Technical Efficiency", *Pakistan Journal of Applied Economies,* 2(2), 1983, 167-180.

Kalirajan, K., "The Importance of Efficient Use in the Adoption of Technology: A Micro Panel Data Analysis", *Journal of Productivity Analysis*, 2:113-126, 1991.

Kalirajan, K.P., and Shand, R.T., "Technology and Farm Performance: Paths of Productive Efficiencies Over Time", *Agricultural Economics*, 24: 297-306, 2001.

Kopp, R.J., and Smith, V.K., "Frontier Production Function Estimates for Steam Electric Generation: A Comparative Analysis", *Econometrics Journal,* 47:1049-1059, 1980.

Kumbakar, S.C., "Efficiency Estimation in A Profit Maximizing Model Using Flexible Production Function", *Agricultural Economics,* 10:143-152, 1994.

Kuznets, S., *Modern Economic Growth: Rate, Structure, and Spread*, New Haven, Yale University Press, 1966.

Meeusen, W., and Van Den Broeck, "Efficiency Estimation from Cobb-Douglas Production Function with Composed Error", *International Economic Review,* 18:435-444, 1977.

Mochebelele, M.T. and Winter-Nelson, A., "Migrant Labor and Farm Technical Efficiency in Lesotho", *World Development*, 28 (1), 2000, 143-153.

Nkamleu, G.B., and Adesina, A.A., "Determinants of Chemical Input Use in Peri-urban Lowland Systems: Bivariate Probit Analysis in Cameroon", *Agricultural Systems 2000*, 63:111-121.

Nyemeck, B.J., *Analyse Comparée de l'Efficacité Economique des Systèmes de Culture: une Approche du Genre dans la Culture du Maïs et de l'Arachide au Centre du Cameroun*, Thèse de Doctorat en Economie Rurale, Abidjan, Université d'Abidjan-CIRES, 1999.

Nyemeck, B.J., Sylla, K., Diarra, I. and Nyambi, G., "Factors Affecting Technical Efficiency among Coffee Farmers in Côte d'Ivoire: An Evidence of Centre West Region", *African Development Review,* 15 (1), 2003, 110-127.

Phillips, M.J., and Marble, R.P., "Farmer Education and Efficiency: A Frontier Production Function Approach", *Economy of Education Review,* 5, 1986, 257-264.

Rahman, S., "Profit Efficiency among Bangladesh Rice Farmers", *Food Policy*, 28:487-503, 2003.

Rawlins, G., "Measuring the Impact of I.R.D.P.II upon the Technical Efficiency Level of Jamaican Peasant Farmers", *Social and Economic Studies,* 34, 1985, 71-96.

Seyoum, E.T., Battese, G.E. and Fleming, E.M., "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, 1998, 341-348.

Shapiro, K.H., et Müller, J., "Sources of Technical Efficiency: The Roles of Modernization and Information", *Economic Development and Cultural Change,* 25, 1977, 293-310.

Sharma, K.R., Leung, P. and Zalleski, H.M., "Technical, Allocative and Economic Efficiencies in Swine Production in Hawaii: A Comparison of Parametric and Non-parametric Approaches", *Agricultural Economics,* 20: 23-35, 1999.

Squires, D., et Tabor, S., "Technical Efficiency and Future Production Gains in Indonesia Agriculture", *The Developing Economics,* 29, 1991, 258-270.

Taylor, T.G., and Shonkwiler, J.S., "Alternative Stochastic Specifications of the Frontier Production Function in the Analysis of Agricultural Credit Programs and Technical Efficiency", *Journal of Development Economics,* 21, 1986, 149-160.

Townsend, R.F., Kirsten, J. and Vink, N., "Farm Size, Productivity and Returns to Scale in Agricultural Revisited: A Case Study of Wine Producers in South Africa", *Agricultural Economics,* 19, 1998, 175-180.

Udry, C., Hoddinott, J., Alderman, H. and Haddad, L., "Gender Differentials in Farm Productivity: Implication for Household Efficiency and Agricultural Policy", *Food Policy,* 20 (5), 1995, 407-423.

Weir, S., "The Effects on Education on Farmer Productivity in Rural Ethiopia", Working Paper CSAE WPS99-7, *Centre for the Study of African Economies,* University of Oxford, 1999.

Weir, S. and Knight, J., "Education Externalities in Rural Ethiopia: Evidence from Average and Stochastic Frontier Production Functions", Working Paper CSAE WWPS-2000.4, *Centre for the Study of African Economies*, University of Oxford, 2000.