Technical Efficiency of Peasant Farmers in northern Ethiopia: A stochastic frontier approach

Zenebe Gebreegziabher*, Arie Oskam** and Tassew Woldehanna***

Abstract

Empirical works on efficiency of small farmers has been triggered by Schultz's (1964) popular *'poor-but-efficient hypothesis'*. Peasant farmers in traditional agricultural settings are reasonably efficient in allocating their resources and they respond positively to price incentives. If farmers are reasonably efficient, as hypothesized by Schultz, then increases in productivity require new inputs and technology to shift the production frontier upward. If, on the other hand, there are significant opportunities to increase productivity through more efficient use of farmers' resources and inputs with current technology, then a better allocation might be essential.

But how to measure and compare their efficiency? The concept of efficiency measurement by means of a frontier method has its origin with Farrell (1957). Several different approaches could be applied (see e.g. Fried et al. .... for an overview). We have chosen for the output-oriented or primal approach, where the central issue is by how much output could be expanded from a given level of inputs.

The empirical analysis uses a stratified sample of farm dataset refers for the 1996 and 1997 production years. Farmers in the sample are located particularly in *Enderta* and *Hintalo-Wajerat* districts of the Tigrai region. A preliminary analysis showed that productivity differences among farmers are rather small (compared to other studies).

There appears to be increasing emphasis by policy-makers on investments in new technologies and inputs rather than efforts aimed at improving the efficiency of less efficient farmers. Obviously, the level of efficiency of peasant (small) farmers has important implications for choice of development strategy. As the choice of development strategy, at least partly rests on the policy makers' conceptions of farm/ farmer-level performances. This analysis is intended to contribute to such strategic choices.

Key words: technical efficiency, stochastic production frontier, peasant farmers, northern Ethiopia.

Draft, April, 2004

*PhD Student, Wageningen University, Tigrai Region Bureau of Agriculture and Natural Resources (BoANRs), P.O. Box 10; Fax: ++251 (0)4 40 37 10; Email: zenebeg2002@yahoo.com
** Professor of Agricultural Economics and Rural Policy, Wageningen University, Netherlands.
*** Assistant Professor, Department of Economics, Addis Ababa University, Ethiopia.

I. Introduction

The concept of efficiency has its origin with Farrel (1957). Most of the research on efficiency of small farmers, however, has been triggered by Schultz's (1964) popular *'poor-but-efficient hypothesis'*; the idea that peasant (small) farmers in traditional agricultural settings are reasonably efficient in allocating their resources and respond positively to price incentives. Indeed, the level of efficiency of peasant (small) farmers has important implications for choice of development strategy. As the choice of development strategy, even if not fully, at least partly rests on the policy makers' conceptions of farm/ farmer-level performances. If farmers are reasonably efficient, as hypothesized by Schultz, then increases in productivity require new inputs and technology to shift the production possibility frontier upward. But, on the other hand, if there are significant opportunities to increase productivity through more efficient use of farmers' resources and inputs with current technology, a stronger case could be made for productivity improvement through ameliorating the factors or determinants of inefficiency. The majority of the empirical works, however, appear to be supporting Schultz's hypothesis which presumably led to increasing emphasis by policy-makers on investments in new technologies and inputs rather than efforts aimed at improving the efficiency of less efficient farmers. Nevertheless, the extent to which peasant farmers in traditional agriculture settings behave consistently according to basic economic rationale still appears controversial (Woldehanna, 2002).

Likewise in Ethiopia, agriculture still plays a major role in the economy of the country and considerable resources are invested on new inputs and technology under the agricultural extension program particularly during the last two decades. Nevertheless, empirical evidences on farmer-level efficiency are very scanty and little work has been done in these respects in Ethiopia. Belete et al (1993), Admassie and Heidhues (1996), and Hailu et al, (1998) appear to be among the very few attempts. Sample farmers in the former two, i.e., Belete et al (1993) and Admassie and Heidhues (1996), belong to the same district, Baso-Warana sub-district in central highlands of Ethiopia. Belete et al (1993) tries to explore the possibilities for improving production and income of small farmers through better allocation of resources under alternative animal cultivation (work oxen acquisition) practices. The study, however, considered a deterministic setting with linear specification. Such a specification ignores the fact that output can be affected by random shocks outside the control of the farmer. The problem with this approach is that the entire shortfall of observed output from maximum feasible output is attributed to technical inefficiency. More importantly, no mention has been made, in the study, about farmer -specific and average levels of efficiency which is of significant policy relevance.

Admassie and Heidhues [1996] tried to investigate and analyze the level of technical efficiency of smallholders using data from two cross-section samples in the central highlands of Ethiopia. That is, using a stochastic frontier production function, it tried to separately determine and compare the level of technical efficiency of the two groups, one representing modern technology users and the other consisting of relatively traditional farmers that do not use modern technology. The fact that both Admassie and Heidhues [1996] and Hailu et al, [1998] used stochastic frontier approach gives them similarity. But, Hailu et al, [1998] was different from the former two in a sense that it tried to investigate the level of inter-farm technical efficiency gap for sample smallholder farmers representing eastern highlands (Oromiya region) of Ethiopia. The central concern/ focus of these two works was on investigating and analyzing the technical efficiency differentials among smallholders, and failed to consider/ determine the factors of inefficiency. Moreover, despite that peasant farmers in Ethiopia and elsewhere in the developing world are constrained by a host of factors including capital shortage, problem of draft power, as well as small and fragmented land holding; Belete et al [1993] only considered and analyzed the problem of draft power. It would be more appealing, however, when all these factors are incorporated into the model and let the model determine as to which of these host of factors are most important ones.

The motivations of this paper are, therefore, twofold: one, to measure technical efficiency of peasant farmers in northern Ethiopia using stochastic frontier approach; and, two, to determine factors causing inefficiency. The novelty in here is that, firstly, it broadens our knowledge about farmer-level technical efficiency by providing insights from Northern Ethiopia. Secondly, it tries to analyze both technical efficiency and factors of inefficiency simultaneously which happen to be a rare case in the literature. The rest of the paper is organized as follows. The next section reviews the role and performance of the agricultural sector in Ethiopia. Section three presents the theoretical framework employed in the study. Section four empirical procedure and data. Section five provides empirical results. Section six draws some concluding remarks.

II. Agriculture in Ethiopia: role and performance

Ethiopia is typically an agrarian country. The bulk of the agricultural output comes from peasant/ smallholder farmers. Mixed crop-livestock farming appear to be the dominant farming strategy in the country. Eighty-one percent of the peasant farmers particularly in the Ethiopian highlands practice mixed farming (Aredo and Lemi, 1999). Nonetheless, the importance of mixed farming system declines as one goes down to the lowlands and nomadic areas. Growth and performance of the agricultural sector, however, has failed to keep pace with the growing demand particularly over the past three decades. As a result, domestic supply problems and food aid dependence has been the typical manifestations of the country.

III. Theoretical framework

There are two approaches to the measurement of technical efficiency: output-oriented approach (often referred to as primal approach) and input-oriented approach (often referred as dual approach). In the primal approach the interest is by how much output could be expanded from a given level of inputs, hence known as output-shortfall. Whereas in the input-oriented approach the concern is the amount by which all inputs could be proportionately reduced to achieve technically efficient level of production, hence, known as input over-use. In this paper preference has been made to the primal approach, given we are considering developing country settings, the concern is rather not that inputs are over-used but output short-fall.

Consider a situation where we have observations on I peasant farmers indexed i=1,..., I, with $x = (x_1,...,x_N) \geq 0$ vector of inputs used to produce an aggregate output $y \geq 0$. Then, the stochastic production frontier model could be specified as

$$y_i = f(x_i;\beta).e^{\phi} \qquad (1)$$

where $f(x_i;\beta)_i$ and e^{ϕ}, respectively, represent the deterministic part and stochastic part of the production frontier, ϕ represents the random error term, and β is a vector of parameters to be estimated.

Besides allowing for technical inefficiency such stochastic production frontier models also acknowledge the fact that random shocks outside the control of the farm operator can affect output. But more importantly, the stochastic production frontier models provide a great virtue that the impact on output of shocks due to variations like in vagaries of the weather, etc can at least in principle be separated from the contribution of variation in technical efficiency (Kumbhakar, 2000).

The total error term in (1) could be decomposed into its respective two components as:

$$\phi_i = v_i + u_i \qquad (2)$$

where v is the symmetric error term accounting for random variations in output due to factors outside the control of the farmer such as weather, disease, plain bad luck, measurement error, etc. Where as u represents the technical in/efficiency relative to the stochastic frontier and assumes only positive values.

The distribution of the symmetric error component v is assumed to be independently and identically as $N(0,\sigma_v^2)$. The normal error term provides the production frontier to be stochastic and, hence, allows the frontier to vary across or over time for the same producer. However, the distribution of the one sided component u is assumed to be half normal. That is, it is assumed to be identically and independently distributed as $N(0,\sigma_u^2)$ and it follows that:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \qquad (3)$$

Following Kumbhakar and Lovell (2000), the *stochastic* production frontier in (1) could also be rewritten as

$$y_i = f(x_i;\beta).\exp\{v_i\}.TE_i \qquad (4)$$

where the stochastic production frontier $[f(x_i;\beta).\exp\{v_i\}]$ consists of two parts: a deterministic part common to all producers and a producer specific part *exp{v$_i$}*, which captures the effect of random noise or shock on each producer. Therefore,

$$TE_i = \frac{y_i}{f(x_i;\beta).\exp\{v_i\}}, \qquad (5)$$

defines technical efficiency as the ratio of observed output to maximum feasible output in an environment characterized by $\exp\{v_i\}$. Equation (5) implies that y_i achieves its maximum feasible value of $[f(x_i;\beta).\exp\{v_i\}]$ if and only if $TE_i = 1$. Otherwise, $TE_i < 1$ provides a measure of the short-fall of observed output from maximum feasible output in an environment characterized by $\exp\{v_i\}$ which varies across peasant farmers and β, as in above, is vector of parameters to be estimated.

Assuming that $f(x_i;\beta)$ takes the log-linear Cobb-Douglas form, then the stochastic production frontier model in Equation (1) could be rewritten as

$$\ln y_i = \ln f(x_i;\beta) + v_i - u_i \qquad (6)$$

where $\varepsilon_i = v_i - u_i$ is the composed error term (Ainger et al, 1977) which is asymmetric. The two-sided 'noise' component v_i $(v \sim N(0,\sigma_v^2))$ and the one-sided efficiency component $u_i \geq 0$ with half-normal distribution $(u \sim |N(0,\sigma_u^2)|)$ are assumed to be independent of each other. Once the model is specified, maximum likelihood estimation of Equation (6) or using the Corrected Ordinary Least Square (COLS), yields estimators for β and λ, where β is as defined earlier, $\lambda = \sigma_u^2 / \sigma_v^2$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$ as defined in Equation (3).

As it could be envisages, the parameter λ is an indicator of the relative variability of the two sources of variations. If λ is closer to zero the symmetric error term dominates the variation between the frontier/ maximum attainable level of output and the observed level of output. Or put differently, a value of λ close to zero implies that the discrepancy between the observed and the maximum attainable levels output is dominated by random factors outside the control of the producer. Otherwise, the more λ is greater than one the more the production is dominated by variability emanating from technical inefficiency.

Once the parameters of the stochastic frontier model are estimated using ML, or COLS, then the Jondrow et al (1982) decomposition technique/ estimators can be used to obtain farmer-specific estimates, $\hat{u}_i$. That is, following Jondrow et al (1982), the above mentioned assumptions on the statistical distributions of v and u would allow us to generate the conditional mean of u_i given ε_i as:

$$E(u_i / \varepsilon_i) = \sigma * \left[\frac{f*(\varepsilon_i \lambda / \sigma)}{1 - F*(\varepsilon_i \lambda / \sigma)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \tag{7}$$

where $F*(.)$ and $f*(.)$ respectively, are the standard normal cumulative and standard normal density functions, evaluated at $\varepsilon_i \lambda / \sigma$, and $\sigma^2 = \sigma_u^2 \sigma_v^2 / \sigma^2$, for λ as defined in above. So that, Equations (6) and (7) provide estimates for v and u after replacing $\varepsilon, \sigma,$ and λ by their estimates.

As the motive in here is also to determine factors contributing to inefficiency besides understanding farmer-level technical efficiency, we need to take explicit account of these factors in our model. Now let's assume that $z = (z_1, ..., z_Q)$ represent the vector of exogenous factors affecting technical inefficiency, which might include age, education, extension contact, involvement in off-farm employment, etc in the case of peasant farmers we are interested in.

Generally, the two-step approach and the 'direct' or 'single step' approaches appear to be the two major approaches that could be pursued to determining or identifying the factors affecting technical inefficiency in agricultural production.

The two-stage approach often involves a two step procedure. In the first step, the model like Equation (6) is estimated under the assumptions that hold with no z variables included and, then, Jondrow et al (1982) estimators used to obtain farmer-specific estimates, $\hat{u}$. In the second step, $\hat{u}$ is regressed on the vector of z variables. That is, run OLS $\hat{u}$ on an intercept and some z variables to obtain estimates of γ. Unfortunately, this approach has serious drawbacks: Firstly, it is assumed that the elements of z_q are uncorrelated with the elements of x_i. ML estimates of $(\beta, \sigma_v^2, \sigma_u^2)$ from Equation (6) under such assumption are biased and inconsistent, unless the x and z variables are true orthogonal. Secondly, in the first step, as in assumption (8a), the mean of u is assumed to be zero and there appears no z variable. But in step two, the attempt is to explain u using a set of z variables which is a contradiction. (Kumbhakar and Knox Lovell, 2000)

Therefore, we followed the second approach, that is, the ‘direct’ or ‘single step’ approach. In the ‘direct’ or ‘single step’ approach the exogenous factors affecting technical inefficiency are included directly in the production function, and specified as

$$\ln y_i = \ln f(x_i, z_q; \beta) + v_i - u_i \tag{8}$$

Assuming that the z_q variable is measured in log, the marginal effect of a z variable on output could be determined as

$$\frac{\partial \ln y}{\partial \ln z_q} = \gamma_q \tag{8a}$$

which also implies

$$\frac{\partial y}{\partial z_q} = \gamma_q \frac{y}{z_q} \tag{8b}$$

In this approach z will, presumably, have two effects: one, it shifts the production technology, upward or downward, depending on the sign of γ; two, it increases or decreases output through reducing or increasing technical inefficiency.

Once the model is specified in such a way, as in Equation (9), then Coelli's Frontier package could be used to carry on the estimation and derive the parameter estimates β and γ as well as farmer-specific technical efficiency. The very reason that we followed this second approach is to come by the aforementioned drawbacks of the two-stage approach.

IV Empirical Procedure and Data

4.1 Empirical procedure

A Cobb-Douglas functional form which includes both the conventional inputs and exogenous factors affecting inefficiency was the one considered in our analysis. Despite its restrictive assumptions, we found the Cobb-Douglas functional form to better fit the data. The specific model estimated was:

$$\ln Y = \beta_0 + \beta_i \ln L + \beta_2 \ln R + \beta_3 \ln X + \beta_4 M + \beta_5 \ln Ox + \gamma_1 Age_1 + \gamma_2 Age_2 + \gamma_3 Age_3 + \gamma_4 Age_4 + \gamma\ Crd + \gamma_6 Gen + \gamma_7 Off + \in . \quad (9)$$

As it could be clear from Equation (9), three categories of variables have been considered in the model; output variable, *x*-variables or the conventional inputs and *z*-variables or exogenous factors assumed to affect inefficiency. The details of the variables considered have been provided in Table 1, below.

Farm labour input (L), area of land cultivated (R), modern inputs (X), value of owned farm implements (M), and Oxen ownership (Ox) were the variables considered as regards to the conventional inputs. Considerable resources are being committed through the extension program, to increase modern inputs (fertilizer, seed, pesticides, etc) utilization of peasant farmers, with more emphasis given to improving production through increasing fertilizer consumption rate of farmers and credit provision. Hence, it would be worthwhile to ascertain whether these efforts could bring about the desired outcome. Following the arguments behind the variable modern inputs was hypothesized to be positively related to output, although the issue is debatable (Taylor and Shonkwiler, 1986). Extension contact was assumed to be implicit in the variable X (modern inputs), in the use of modern inputs such as fertilizer and, hence, excluded from consideration to avoid co-linearity. Number of oxen owned was hypothesized to have positive effect on efficiency. Considerable number of peasant farmers in the area do not own ox. Most often, farmers who have one ox plow their fields by joining hands with others / peer. It could be envisaged that lack of adequate draught power leads to delay and poor land preparation, inefficient farm operations and late planting with a major depressing effect on yield.

Access to credit, age of farmer, gender, and involvement in off-farm employment constitute *z*-variables considered in the model. The choice of such particular *z*-variables was largely based on economic arguments. Access to credit offers a characterization of the degree of market development or competitiveness. Consideration was also made only for age of farmer and education of farmer was excluded from consideration because of the absence of significant difference in level of education among the peasant farmers considered. The effect of age of farmer on efficiency was anticipated to be either positive or negative; as age increases there is an experience effect which is efficiency increasing (potentially). However, as the old age is approached the capacity to do work might decrease. Old aged farmers are also less receptive to new inputs and technologies, implying negative relationship. To capture these different effects, four categories of age of farmer were considered (Table 1). This was measured visa-vis those with less or equal to thirty years. Gender of farmer as specified in the model was anticipated to be negatively related to efficiency. The presumption is that, firstly, women in the area do not carry on plowing by themselves. The practice is either they rent out their land for sharecropper or look for somebody/ relative who does the plowing operation, which affect timely operation and/ or size of harvest. Secondly, women might have constrained access to credit and modern inputs for various reasons which also confer the negative relationship.

The effect of involvement in non-farm activities on efficiency might possibly be mixed, that is, both positive and negative. By acting as a residual sector that absorbs the workers who cannot be readily absorbed in agriculture, the rural non-farm sector might contribute to improved farm productivity of peasant households, through its income effect, by relaxing their capital or liquidity constraint and allowing the purchase of inputs such as farm labor, seeds, fertilizer and pesticides (Woldehanna, 2000). That is, in situations of the existence of idle labor and wage income from off-farm employment being, at least partly, reinvested in agriculture, a positive effect on efficiency might be anticipated. On the other extreme, when there is no idle labor and involvement in off-farm activities competes with labor for agriculture, it could be the case that it has negative effect on efficiency. On the balance, the net effect of involvement in non-farm activities was hypothesized to be either positive or negative, depending on the relative magnitude of the two effects.

Once variables were chosen and model specified, then Coelli's Frontier 4.1 was used for estimation.

Table 1 Definition and measurement of variables considered in equation (9)

Variable category	Variable name	Measurement method
Output	Aggregate crop output (Y)	Value of crop output in *Birr*
x-variables (conventional inputs)	(i) Labour (L)	Quantity of farm labour hours worked
	(ii) Land cultivated (R)	Area in '*tsimdi*'[1]
	(iii) Modern inputs (X)	Value in *Birr*[2]
	(iv) Farm implements (M)	Value of owned implements in *Birr*
	(v) Oxen owned (Ox)	Number of owned oxen
z-variables (exogenous factors)	(i) Access to credit (Crd)	As a dummy variable having a value of 1if yes, 0 otherwise
	(ii) Age category of farmer	
	Age>30$\leq$40 (Age_1)	As a dummy variable having a value of 1if yes, 0 otherwise
	Age>40$\leq$50 (Age_2)	Same as above
	Age>50$\leq$60 (Age_3)	Same as above
	Age>60 (Age_4)	Same as above
	(iii) Gender of farmer (Gen)	As a dummy variable having a value of 1if female, 0 otherwise
	(iv) Off-farm activities (Off)	As a dummy variable having a value of 1 if the farmer is involved in off-farm activities, 0 otherwise

[1] *tsimdi* is a local area unit 1*tsimdi*=0.25ha

[2] *Birr* is Ethiopian currency currently 1USD=8.61*Birr* and 1USD=7.00 *Birr* during the period the data was collected.

4.2 Data Description

The dataset used in this paper come from a random sample of peasant farmers in northern Ethiopia. A two period (two production year) data from 176 cross-sections of peasant households was obtained. The data set refers to 1996 and 1997 production years and farmers in the sample are located particularly in *Enderta* and *Hintalo-Wajerat* districts of the Tigrai region. The description of the dataset has been provided in Table 2. About 13 percent of the households considered were females.

Table 2 Description of the data set (n=352)

Variables	Mean	Std. Dev.	Min	Max
Family size	5.58	2.15	1	11
Age of household head	48	11.83	25	76
Area of land cultivated (in *tsimdi*)	7.06	4.7	0	24
Value of owned farm implements	237.62	185.71	0	1,427
Total livestock wealth	3,616	5,298	0	63,700
Value of modern inputs	72..99	147.85	0	1075
Number of oxen owned	1.55	1.09	0	6
Value of crop output	1,962.04	1,911.46	0	15,000

Peasant households in the area are involved in farm and off-farm activities. About 36 percent of the peasant households were found to be involved in off-farm activities. Mixed crop-livestock farming is the dominant system in the area. Crops grown by peasant farmers include lentils, vetch, linseed, and vegetables with barley, wheat, teff, and sorghum being the four most important crops in order of importance. Most of the peasant agriculture is practiced under rain-fed condition.

V. Empirical results

Table 3 shows the maximum likelihood parameter estimates of the stochastic production frontier (i.e., equation 6). For comparison, OLS estimates have also been provided. The ML estimates the β parameter show that from among *x*-variables (the conventional inputs) only the parameter for land input and number of oxen owned were found to be significant. The parameter estimate for modern input turned out to be insignificant, which was contrary to the expectation. Implying that use of modern inputs has no significant effect on productivity. This raises doubts about the feasibility of the efforts being committed on the extension program. The possible reasons for the parameter estimate to turn out insignificant might be: One, it could, indeed, be the case that modern inputs have no significant effect on output and that emphasizing increased use of external inputs might not be worthwhile for typical dryland areas for which the data represents. Two , alternatively, it could be due to the aggregation of output over various crops including those not covered by the extension program that the net effect of modern inputs is not discernible. It could also be because of the restrictive condition of the Cob-Douglas specification of model.

ML estimates of the γ parameters also showed that among all the variables considered only the variable for involvement in off-farm activities is significant. Whereas the variables access to credit, age and gender of farmer found to have no significant impact on inefficiency. But, the sign of parameter estimate for gender was found to be negative in line with what was expected. The parameter estimate for the variable off-farm activities was significant but negative. Although up to expectation, this was in a way contrary to earlier finding (Woldehanna, 2000).

In general, the analysis showed an average technical efficiency of 80.1%. About 85 percent of the peasant farmers were found to have an efficiency level above 75% (Table 4). The fact that the average efficiency level is relatively higher, perhaps compared to studies in other countries (Bravo-Ureta and Evenson, 1994), suggests that there is little room for efficiency improvement, given current technology, supporting Schultz's hypothesis. The reason that the variable for modern inputs turned out insignificant could probably be because the new inputs are not used at their full scale/ recommended rate. But, more importantly, it could probably be because farmers need some time to eventually adjust to a reasonably efficient use of the new/ modern inputs through learning by doing (Ali and Byerlee, 1991).

Table 3. Estimation results (standard error in parenthesis)

Variable	Estimator	
	OLS	MLE
Labor	0.495	0.028
	(0.265)	(0.059)
Land	0.115	0.535***
	(0.411)	(0.086)
Modern inputs	0.009	0.003
	(0.008)	(0.007)
Value of owned farm implements	0.030	0.030
	(0.047)	(0.041)
Number of oxen owned	0.147	0.070***
	(0.025)	(0.022)
Access to credit		0.023
		(0.043)
Age category of farmer		
Age>30≤40		0.031
		(0.098)
Age>40≤50		0.006
		(0.097
Age>50≤60		0.018
		(0.099)
Age>60		0.041
		(0.103)

Table 3 continued

Gender of farmer	0.587	-0.038
	(0.208)	(0.163)
Off-farm activities	-0.215	-0.165***
	(0.060)	(0.051)
Intercept	0.504	2.623***
	(0.114)	(0.222)
λ		192.87
		(9.88)
σ^2		24.33
		(0.097)
Log likelihood function		-161.651

***, significant at 0.01 level.

Table 4 Frequency distribution of technical efficiency estimates of sample peasant farmers by category of efficiency level (by district)

level	Enderta (n=81)	Hintalo-Wajirat (n=95)	Total sample (n=176)
>0.85	16	7	23
>0.75 $\leq$ 0.85	58	65	123
>0.65 $\leq$ 0.75	6	23	29
>0.55 $\leq$ 0.65	0	0	0
>0.45 $\leq$ 0.55	0	0	0
$\leq$ 0.45	1	0	1
Mean (%)	81.50	78.94	80.11
Minimum (%)	15.95	66.55	15.95
Maximum (%)	89.26	89.66	89.66

VI. Conclusions

This paper used a stochastic frontier approach to derive farmer-specific technical efficiency and simultaneously determine the socioeconomic factors affecting inefficiency for a sample of peasant farmers from northern Ethiopia. The analysis was performed for the aggregate value of annual crop output. The analysis showed an average technical efficiency of 80.1%. About 85 percent of the peasant farmers were found to have an efficiency level above 75%. The fact that the average efficiency level is relatively higher, perhaps compared to studies in other countries, suggests that there is little room for efficiency improvement, given current technology, supporting Schultz's hypothesis. The reason that the variable for modern inputs turned out insignificant could probably be because the new inputs are not used at their full scale/ recommended rate. But, more importantly, it could probably be because farmers need some time to eventually adjust to a reasonably efficient use of the new/ modern inputs through learning by doing. Perhaps, this might call for further careful analysis in a multi output framework to check for discernible crop specific effects of modern inputs. If, however, it is indeed the case that modern inputs do not have discernible crop specific effect, our finding would perhaps pose a challenge on the emphasis in the use of modern inputs. Of all the variables considered, gains in output stemming from relaxing the land constraint as well as problem of draft power appear to be the most important ones to the region. Our empirical findings suggest that relaxing the oxen constraint by one unit (100%), ceteris paribus, improves output by 7 percent.

A close examination of the relationship between output and the various socioeconomic variables assumed to determine inefficiency also reveals a clear strategy, also consistent with overall model finding, that could be suggested to improve performance. Technically speaking gender of farmer was found to have no significant effect on inefficiency. Perhaps this could be because share cropping arrangements are reasonably efficient. Though the interpretation may not be that straight forward, as in the variables specified in logs, involvement in off-farm activities was found to have significant negative effect on farm production. May be because, on the balance the labor competing effect of involvement in off-farm activities outweighs the liquidity relaxing (income) effect.

References

Admassie, Assefa and Heidhues, Franz (1996). ‘Estimation of Technical Efficiency of Smallholder Farmers in the Central Highlands of Ethiopia”, Ethiopian Journal of Agricultural Economics 1(1):19-35.

Ainger, D., C.A. Knox Lovell, and P. Schmidt (1977). “Formulation and Estimation of Stochastic Frontier Production Function Models”, Journal of Econometrics 6:21-37.

Ali , M. and D. Byerlee (1991). "Economic efficiency of small farmers in a changing world: a survey of recent evidence", Journal of International Development 3(1):1-27.

Aredo, Dejene and Lemi, Adugna (1999). ‘The Crop-Livestock Systems and Contributions to the Economy: A Review of empirical Evidences’, in: Economics of Integration and crop-Livestock Systems in Ethiopia, Proceedings of the 3rd Conference of the Agricultural Economics Society of Ethiopia, Mulat Demeke and Woday Amha (eds), pp1-36.

Belete, Abnet, J.L. Dillon, and F.M. Anderson (1991). "Development of Agriculture in Ethiopia since the 1975 land reform", Agricultural Economics 6:159-175.

__________ 1993. "Efficiency of small-scale farmers in Ethiopia: a case study in the Baso and Warana sub-districts", Agricultural Economics 8:199-209.

Bravo-Ureta, B.E. and R.E. Evansen (1994). "Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay", Agricultural Economics 10:27-37.

Coelli, T. (1996). A Guide to Frontier Version 4.1. A Computer Program for Stochastic Frontier and Cost Function Estimation, CEPA Working paper 96/07.

Farrell, M. J. (1957). “The measurement of productive efficiency”, Journal of Royal Statistical Society, (Series A), 120:253-281.

Gebremeddhin, B., J. Pender and S. Ehui (2002). Land use, land tenure and sustainable land management in Tigrai, Policies for sustainable land management in the highlands of Tigrai, nothern Ethiopia, Mekele University, IFPRI, and ILRI.

Greene, W. H. (1990). “A Gamma Distributed Stochastic Frontier Model”, Journal of Econometric 46:141-163

____________ (1980). “Maximum Likelihood Estimation of Econometric Frontier Functions”, Journal of Econometrics13:27-56.

Hailu, Getu, V. Bitsch, B. Kassa, and H. Storck (1998). “Technical Efficiencies of Smallholder annual Crop Production in Moisture Stress area of Eastern Oromiya of Ethiopia: A Stochastic Frontier Analysis”, Ethiopian Journal of Agricultural Economics 2(2): 91-115.

Jondrow, J., C. A. Knox Lovell, I. S. Materov, and P. Schmidt (1982). "On the Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model", Journal of Econometrics 19:233-238.

Kumbhakar, S. C. and C.A. Knox Lovell (2000). Stochastic Frontier Analysis. Cambridge University Press.

Ondrich, Jan and John Ruggiero (2001). “Efficiency measurement in the stochastic frontier model”, European Journal of Operations Research 129: 434-442.

Schultz, T. W. (1964). Transforming Traditional Agricultural. Chicago: University of Chicago Press.

Shapiro, K,H. (1983). "Efficiency differentials in peasant agriculture and their implications for development policies", Journal of Development Studies 19:179-190.

Taylor, T. G. and J.S. Shonkwiler (1986). "Alternative stochastic specification of the frontier production function in the analysis of agricultural credit program and technical efficiency, Journal of Development Economics 21:149-160.

Thiam, A., B. E Bravo-Ureta, and T.E. Rivas (2001). “Technical efficiency in developing country agriculture: a meta-analysis”, Agricultural Economics 25:235-243.

Woldehanna, T. (2000). Economic Analysis and Policy implications of Farm and Off-farm Employment: A Case Study in Tigrai Region of Northern Ethiopia.