Ethiopian Journal of Economics

Volume V | Number 1 | April 1996

The **Ethiopian Journal of Economics** is a publication of the Ethiopian Economic Association. It is a bi-annual, (numbers one and two of each volume appearing in April and October of each calendar year) devoted to the advancement of economic science in Ethiopia. However, contributions by non-Ethiopians and on economic experiences of other lands are considered for publication. All communication (i.e. subscription, editorial and other) may be addressed to the Editor on one of the following addresses:

The Ethiopian Economic Association
P.O. Box 34282
Addis Ababa
ETHIOPIA

Or

Economics Department
Addis Ababa University
P.O.Box 1176
Addis Ababa
ETHIOPIA

Subscription Rates (surface mail) 1995

Per Copy/local

Annual	Birr 10
	US$
Africa	15
Others	18
Per copy	9
Back issues	10

Volume V Number 1 April 1996

Ethiopian Journal of Economics

A Publication of
THE ETHIOPIAN ECONOMIC ASSOCIATION
(EEA)

Ethiopian Journal of Economics

Volume V | **Number 1** | **April 1996**

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, PP. 1-27

THE IMPACT OF EDUCATION ON ALLOCATIVE AND TECHNICAL EFFICIENCY OF FARMERS: THE CASE OF ETHIOPIAN SMALL HOLDERS

Abay Asfaw and Assefa Admassie*

ABSTRACT: *As the potential to increase production by bringing more resources into use becomes more and more limited, it is natural that the efficiency with which firms or farmers use available resources would become more important as a topic of investigation. This study attempts to examine the impact of education on technical and allocative efficiency of farmers using the frontier profit function approach. The result of the stochastic profit frontier functions show that there are considerable amount of deviations from the optimal profit efficiency level. It specifically shows that the mean level of profit efficiency in the sampled farmers is 54.0 percent suggesting that the level of profit inefficiency could be as high as 46 percent. The hypothesis of equal allocative and technical efficiency of educated and illiterate farmers was tested using the modified Y-L profit function model under various linear restrictions and the result revealed that educated farmers are relatively and absolutely more efficient than illiterate farmers. This implies that at the existing level of factor endowments and technology there is a potential to increase agricultural output by raising the education level of farmers and consequently, by making illiterate farmers operate more closer to the efficiency level achieved by their educated neighbours.*

1. INTRODUCTION

One of the most important issues in human capital theory is to know the contribution of human capital to economic development. Various researchers in many parts of the world have been trying to analyse the effects of human capital on the economy of a given country both at the macro and micro levels using methods ranging from simple arithmetic tools to complicated econometric models.

Education is hypothesised to affect agricultural productivity at least in two different ways. First, education increases the ability of farmers to produce more output from given resources. This is the marginal product of education or using Welch's words it is the workers' effect (Welch, 1971). Secondly, education may enhance the ability of a farmer to obtain and analyse information and to adjust quickly to disequilibria. Thus, education changes the type and magnitude of inputs to be used in production that otherwise would have not been occurred (Welch, 1971). This is known as the allocative effect of education.

With the growing interest in human capital theory, analysing the impact of education on economic growth and especially on efficiency has been increasing from time to time. There is a crucial need

* *Abay Asfaw is lecturer in Economics Department of the Ethiopian Civil Service College ; and Assefa Admassie is Assistant Professor, Department of Economics, Addis Ababa University. The article is based on Msc. thesis submitted to the Department of Economics, Addis Ababa University.*

to study the impact of education on agricultural efficiency in Ethiopia mainly due to the following reasons.

First, during the last three decades, on the average 12 percent of the total amount of government's annual expenditure was allocated to the educational sector. Different education plans have been also drafted and implemented. The central belief in all of the above efforts was and still is the thinking that accumulation of knowledge through education is a major decisive factor in economic development. If education has any impact on the economic development of Ethiopia it has to be reflected on the agricultural sector which is the dominant sector. The agricultural sector directly or indirectly provides the livelihood for more than 90 percent of the population, generates nearly half of the GDP, and contributes more than 90 percent to the total export revenue. In a situation where the agricultural sector has been seen as an energiser and pre-requisite for over all development, and in an environment where there is a strong exercise to restructure the education system, there is a need to asses the impact of education on the efficiency of the agricultural producers.

Secondly, the transition from the centrally planned to the market economy has changed the equilibrium prices of agricultural inputs and outputs. Even without these changes, the physical and demographic situations in which farmers have been operating are in continuos disturbances. All these changes need quick adjustments. This study examines the impact of education on farmers' ability to adjust to profit maximising points.

Finally, in a country like Ethiopia where the possibility of increasing agricultural outputs through expansion of arable land (at the expense of the environment and grazing lands) and increasing the supply of modern inputs are remote possibilities (at least from the farmers point of view), there is a great demand for an alternative solution to the problem at least in the short run. This study tries to assess if there is any short run and relatively inexpensive possibility to increase agricultural output using only the existing farmers' resource endowments and farming technology.

2. OBJECTIVES OF THE STUDY

The main objective of the study is to analyse the impact of farmers' education on the efficiency of Ethiopian smallholders and thereby show whether there are possibilities to increase agricultural outputs not only through increasing investments on new inputs and technologies but by raising the level of farmers' education. Specifically, the study has the following objectives.

- To empirically asses the existence of profit efficiency differentials among smallholders in Ethiopia;
- To test empirically the impact of farmers' education on their allocative and technical efficiency levels.

3. REVIEW OF THE LITERATURE

3.1 Introduction

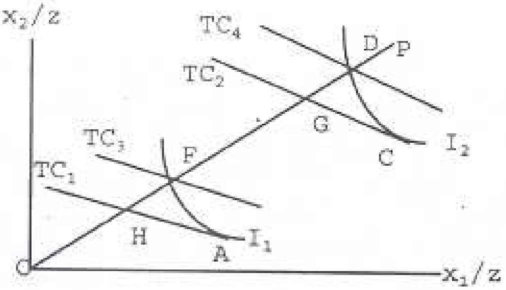
The traditional economic theory of the firm which presupposes technical efficiency and/or perfect and free information, pushes aside the matter of inefficiency by neglecting the role of education or the differences in human factor from the analysis of production. However, various recent studies revealed that a large part of the growth in per capita income is attributable to the stock of productive skills and knowledge accumulated through education. Aside from its contribution to macro economic development, it is hypothesised that education affects agricultural productivity by improving both the allocative and technical efficiency of farmers.

3.2 The Meaning of Allocative and Technical Efficiency

Allocative efficiency (AE) can be defined as the ability of a farm to maximise profit by equating marginal revenue product of inputs to their respective marginal costs. It arises from a choice of better utilisation of the existing inputs. Technical efficiency (TE) is defined as the ability of a farm to produce maximum output from a given bundle of inputs. The difference between these two concepts of overall efficiency can be easily and clearly presented using the following diagram following the work of Farrell (1957).

Given the price of two variable inputs say x_1 & x_2 and total output (z), maximum efficiency in production is achieved when the producer uses the best production function (I) and equates the marginal value product of each variable input to its market price. Point A which is the intersection point of the isoquant curve I_1 (which shows the most efficient input utilisation curve per unit of output) and the total variable cost curve TC1 (which represents the minimum cost level) depicts the most efficient production point.

Fig. 1. Allocative and Technical Efficiency in the Case of One Ouput and Two Inputs



Source : Sadoulte and Janvry, 1995, p. 243

If a certain farm is producing at point D, the total inefficiency of this farm can be decomposed into TE and AE using the maximum efficiency point A as a reference point. Differences in TE arises from differences in total variable cost incurred per unit of output. Even though point D and F are on the same line OP (have the same factor proportions), the total variable cost required to produce one unit of output at F is less than at point D. Therefore the TE of the farmer at point D in the factor space can be represented by the ratio of the lower total variable cost (TC3) and the observed total variable cost TC4. This is the same as the ratio of line OF to OD. Note that the difference in TE between point F & D are not usually considered by traditional economic theories which presuppose a minimum physical input per unit of output according to the latest technology (Moock, 1981).

Allocative inefficiency arises from the failure of farmers to equate the marginal value product of each inputs (given by the slope of the isoquant curves) to its marginal cost (given by the slope of the TC lines) given input and output prices. If we don't assume TE i.e., if we consider the current technology, point C represents the best allocatively efficient point since I_2 is tangent to the total variable cost line TC_2. Thus, a farm that operates at point D is allocatively inefficient by the cost gap TC_4-TC_3. On the other hand, if we presuppose TE, but not AE, the farm which produces at points like F , i.e., along the best practice line I_1, incurs TC3-TC1 amount of profit loss due to allocative inefficiency. Thus, a farm is economically efficient if it operates at point A where the requirements for both technical and allocative efficiencies are satisfied.

3.3 Measurement of Efficiency

3..3.1 Engineering Approach

An engineering production function can be used to investigate the effect of education on efficiency. Given the production function Q = f(X,E), where Q is the physical output and X and E represent the various inputs and education components respectively, the marginal product of education is given by $\partial Q/\partial E$.

The elasticity of output with respect to education (education can be approximated by years of schooling, farmers exposure to extension services, etc.) and the marginal increase in output as a result of a change in education can be estimated by modelling the above relation using an appropriate functional form.

Various researchers have adopted the engineering approach to estimate the contribution of education to agricultural productivity (for a good survey see Lockneed *et al*, 1980) and Phillips, (1994). They found a positive and significant workers' effect of education. However, the engineering approach is bounded with many theoretical and empirical problems. As pointed out by Welch, the marginal productivity of education derived from the engineering production function measures the 'workers' effect' only since it considers inputs as given (Welch, 1971). In other words $\partial Q/\partial E$ shows only the worker effect and it does not capture the allocative effect of education which increases the productive ability of workers by helping them to choose more efficient and optimal output mix and input use as well as a more appropriate scale (Ram, 1980 and Førsund *et al*, 1980). A further limitation of the engineering production function is that if we do not assume farmers are maximising expected profits, the estimation of the equation by OLS yields biased and inconsistent estimates of the coefficients due to simultaneous equation bias. Hence, a better model is required so as to capture both the allocative and worker effects of education.

3.3.2 The Profit Function Approach

The profit function is presented as a superior alternative to the engineering function since it would avoid the above limitations. The profit function can be derived from a production function given the price of output and inputs and fixed factors of production. Given n variable inputs **X** =($x_1,x_2,...,x_n$), and m fixed inputs **Z** =($z_1,z_2,...,z_m$) and a vector of expected prices for variable inputs W=($w_1,w_2,...,w_n$) the maximum attainable output is given by **f(X,Z)**, and then the maximum restricted profit (total revenue less variable cost only) will be $\Pi(\mathbf{P},\mathbf{W},\mathbf{Z}) = \max_{Y,X}\{PY - W'X / f(X,Z) \geq Y, X \geq 0, Y \geq 0\}$ where **P** is the price of the output **Y** (Førsund *et al*, 1980). Profit maximising demand and supply functions can be easily derived from the profit function using Hotelling's lemma, as

$$\frac{\partial\Pi}{\partial p}(P,W,Z) = Y$$

and

$$\frac{\partial\pi}{\partial W}(P,W,Z) = -X$$

respectively. If we have only one output, the profit level and input prices can be divided by price of output so as to get restricted normalised profit and normalised input prices.

The importance of the profit function in estimating the effect of education on both allocative and technical efficiency is stressed by various authors (see for instance, Lau & Yotopoulos 1971; Pudasaini, 1983; Ali & Flinn, 1989; Sadoulet & Janvry, 1995). These authors have argued that (i) since the profit and the input demand functions are expressed in terms of exogenous variables, i.e., in terms of price of inputs and outputs and fixed inputs there is no simultaneous equation bias when these functions are estimated; and (ii) both the allocative and technical efficiency effect of education and the relative efficiency of educated and illiterate farmers can be estimated.

Moreover, if farmers face different prices and have unequal amount of fixed inputs such as land, family labour, etc., the production function method may not give appropriate picture about their economic efficiency since the best-practice production function and, consequently, the optimal operating point is different for different farmers. Emphasising the superiority of the profit function Kalirajan stated that

> The production behaviour of farmers can be well explained by the profit function because it incorporates the pre-determined variables (prices) as explaining variables and it allows for imperfect maximisation by the farmers. The profit function also allows for farmers paying and receiving different prices for homogenous variable factors of production and output respectively, and for farms having varying quantities of fixed factors of production. Thus it allows for inter-farm differences in equating the marginal value product of variable inputs with their prices....Economic efficiency, incorporating its two components of technical and price (allocative) efficiency, can thus be adequately explained by the profit function approach (Kalirajan, 1992: 308-309).

Based on the work of Yotopoulos and Lau (Y-L) (1973) many other authors sush as Levy (1981), Pudasaini (1983), Saleem (1988), and Kalirajan (1992) used the profit function to test the allocative and technical efficiency differentials of farmers based on their economic and social characteristics such as education. Basically, they jointly estimated a restricted profit function and the corresponding profit maximising input demand equations of the form,

$$\ln \prod = \ln \alpha_0 + \delta^1 D^1 + \beta_i \ln W_i + \gamma_j \ln Z_j + U_i \qquad [1]$$

$$\frac{-W_i X_i}{\prod} = \beta *_i D^1 + \beta *_i D^2 + V_i, \quad i = 1, 2, ...n \qquad [2]$$

Where:

Π_i	= restricted profit
W_i	= variable input prices
Z_j	= fixed inputs
D1 and D2	= some different characteristics of farmers such as small and large, or literate and illiterate , etc.,.
i	= the i^{th} house hold

α_o, δ, β_i ,γ_j,$\beta^*{}_1$, = coefficents to be estimated from the profit and input demand functions

This formulation helps to avoid simultaneous equation bias and to separate the allocative efficiency errors from the random errors. Farmers may fail to use an optimal amount of inputs or may unable to equate the marginal product of each input to its price not only due to factors under their control *per se*, but also owing to exogenous shocks which are out of their control, (Kumbhakar, 1988 and Maddala, 1992). Thus, in equations [1] and [2] above U and V represent statistical errors and other exogenous factors which are out of the control of the decision maker such as weather, 'divergence between expected and realised prices', etc.

By estimating the above two equations and the accompanying constraints using Zellner's seemingly unrelated regression method, different hypotheses can be readily tested. For instance,

i. *Equal relative economic efficiency of the two groups*: This hypothesis is equivalent to saying that the two groups have identical restricted profit and factor demand functions and this is 'equivalent to testing whether the coefficient of the dummy variable differentiating the two profit functions is Zero' (Kalirajan, 1992: 308). The source of difference in relative economic efficiency can be due to technical inefficiency alone or allocative inefficiency alone or due to some combinations of the two (Førsund *et al.* 1980). The formulation of the profit function helps to test these efficiency differentials of the two groups separately.

ii. *Equal relative efficiency*: The two groups are allocatively efficient if they equate the marginal value product of each variable input to its market price. 'This is equivalent to testing the hypothesis that the elasticities of variable inputs of (the two groups) estimated from their factor demand functions are the same' (Kalirajan, 1992: 308).

Equal economic efficiency: This involves testing equal relative and allocative efficiency.

iv. *Absolute allocative efficiency:* This tests which groups of farmers achive absolute allocative efficiency.

Based on this approach Pudasani (1983) for Nepal, Saleem (1988) for Sudan, and Kalirajan (1993) for India, investigated the allocative, technical and overall economic differentials between two different groups of farmers. For instance Pudasani concluded that: (a) farmers' education contributed to output most significantly through its allocative effect rather than through its worker (technical) effect even in a single output farm characterised by changing technology, and (b) the profit function approach captures the allocative effect of education more clearly than the production function model (Pudasaini, 1983).

The use of the profit function model is not, however, without limitations. As argued by Aigner, Lovel and Schmidet (1977) such functions do not allow to estimate farm specific efficiency levels. This limitation led to the development of the frontier models to estimate efficiency levels which are believed to over come the limitations of the Y-L type profit models.

3.3.3 Frontier Models

The importance of stochastic frontier against the Y-L and the deterministic frontier models is emphasised in recent studies. The concept, types, historical development , associated assumptions, and limitations of various forms of frontier production functions are intensively discussed in literature (see for instance Førsund, *et.al* ,1980 and Assefa, 1995) The word frontier indicates the maximum limit of a production or profit function which can be derived from given quantities of inputs and their prices and in the case of cost functions the minimum level of cost that is required to produce a certain output. 'The amounts by which a firm lies below its production and profit frontiers, can be regarded as measures of inefficiency' (Førsud *et al*, 1980:5).

Theoretically the production, profit and cost frontier functions can be derived, given data on input and output prices. The function which shows the maximum attainable output level $f(X,Z)$, the maximum profit level $\Pi(P,W,Z)$, and the minimum cost requirement $C(Y,W)$, that were mentioned earlier can be taken as frontier functions since they show the maximum (in the case of $f(X,Z)$ and $\Pi(P,W,Z)$) and the minimum (in the case of $C(Y,W)$) limits. If we assume that a certain farm is producing output Y^1 by using variable inputs X^1 and fixed inputs Z^1, the farm will be technically efficient if $Y^1 = f(X^1,Z^1)$. The technical efficiency of this farm can then be measured by the ratio of the actual output Y^1 and the maximum possible output $f(X^1,Z^1)$ which is in the range of 0 and 1 inclusive.

If $Y^1 < f(X^1,Z^1)$ the farmer is not on the production frontier and, consequently, since technical inefficiency is nothing but using excess resources to produce a given output, $W'X^1 > C(Y^1,W,Z^1)$ and the corresponding profit level will be less than the maximum and is given by $(PY^1\text{-}W'X^1/Z^1) < \Pi(P,W,Z^1)$ (Førsund *et al* ,1980). The allocative efficiency of this particular farm can also be analysed by using the above functions. The observed production level (Y^1,X^1) is said to be allocatively inefficient if $f_i(X^1,Z^1)/(f_j(X^1,Z^1)) \neq W_i/W_j$ i.e., if the farmer fails to equate the ratio of the marginal value product of variable inputs say i and j to their price ratio. As allocative inefficiency implies using inputs in non-optimal production, the cost will not be minimised and, consequently, the profit level will not be the maximum possible. Thus, $W'X^1 > C(Y^1,W,Z^1)$ and $(PY^1\text{-}W'X^1/Z) < \Pi(P,W,Z^1)$. Førsund *et al* (1980) indicated that 'Observed expenditure $W'X^1$ coincides with minimum cost $C(Y^1,W,Z^1)$ if, and only if, the firm is both technically and allocatively efficient'.

The translation of this theoretical presentation of the frontier functions into concrete estimation procedure can be accomplished by considering a hypothetical frontier production function such as the one given by Kalirajan and Shand (1989). Thus, if we consider the model:

$$Y_{it} = b_0 \Pi (X_{ijt})^{bj} e^{\varepsilon_{it}} \qquad [3]$$

ε_{it} will take care of the deviation of the actual output from the frontier line. In other words ε_{it} will be 0 if, and only if, the i^{th} farm is technically efficient and will be strictly negative otherwise.

$$\text{Define } \varepsilon_{it} = U_{it} + V_{it} \qquad [4]$$

Where V_{it} is asymmetric component of the error term which measures exogenous shocks and statistical errors. The one sided component ($U_{it} \leq 0$) captures the divergence of the actual output from the best practice and consequently measures 'technical efficiency relative to the stochastic frontier' $\mathbf{Y_{it} = b_o \Pi (X_{ijt})^{bj} e^{\varepsilon_{it}}}$, (Dawson *et al* ,1991).

Thus, the above equation can be written as

$$\mathbf{Y_{it} = b_o \; \Pi(X_{ijt})^{bj} e^{(U_{it}+V_{it})}} \qquad [5]$$

Following Aigner *et al* (1977) and Meeusen and Broeck (1977) the above equation can be estimated by maximum likelihood methods, (Dawson *et al* ,1991). If U_{it} is not included in the equation it will be reduced to an average frontier function by which estimation of firm specific efficiency is impossible. If V_{it} is absent, the model will be deterministic and it will lose its stochastic nature (Ali and Flinn ,1989).

The derivation of farm specific estimates of efficiency was first demonstrated by Jondrow *et al.* (1982) who assumed a half-normal distribution for U_{it} and a full normal distribution for V_{it}. Once the assumptions are made, firm specific technical efficiency 'is obtained by calculating the mean of the conditional distribution of the inefficiency error (U_i) given the total error ($U_i + V_i$)', (Hill and Kalirajan 1993) as

$$E(U_i/(U_i+V_i)) = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{\phi(.)}{1-\Phi(.)} - \left(\frac{U_i+V_i}{\sigma}\right)\left(\frac{\gamma}{1-\gamma}\right)^{1/2}\right] \qquad [6]$$

Where

$\gamma=\sigma^2_U/\sigma^2$, $\sigma^2=\sigma^2_U+\sigma^2_V$ and $\phi(.)$ and $\Phi(.)$ are standard normal density and cumulative distribution functions evaluated at $[(U+V)/\sigma][(\gamma/(1-\gamma))^{1/2}]$, respectively.

Based on this basic principle various researchers tried to measure not only technical efficiency which is given by e^{Uit} but also allocative efficiency of agents. Almost all frontier model studies reviewed in this paper concluded that education (both formal and informal) is positively related with efficiency (Alli and Flinn, 1989 ; Ekayanake, 1978; and Wu, 1977).

The achievement in estimating firm specific efficiency levels from stochastic frontier functions has given the profit function a new dimension. Concerning the progress in the profit function approach Ali and Flinn wrote 'Estimating firm-specific inefficiency via a profit frontier approach is a theoretical improvement over the past production frontier approach because it takes into account firm specific prices' (Ali and Flinn, 1991: 309). Many researchers have been exploiting these opportunities to test not only farm specific efficiency differentials of farmers but also to identify socio-economic factors related to efficiency (Ekayanake, 1987; Ali and Flinn, 1989; and Umesha and Bisaliah, 1991). The method followed by many researches to analyse the impact of socio-economic variables on efficiency has three distinct stages. At the first stage the stochastic frontier profit (or production) function is estimated and at the second stage farm specific profit efficiency (TE and AE) measures are calculated. At the last stage various socio-economic variables are used to explain the efficiency differentials.

Almost all studies, but one, that we have reviewed concluded that education (both formal and informal) is positively related with efficiency. Some of the conclusions made by different authors for various countries are:

'Farm households with more education exhibited significantly less loss of profit than those with less education. Indeed, based on its contribution to R^2, education was the single most important determinant' (for farmers in Pakistan Punjab, Ali and Flinn,1989: 308).

'Literacy, defined as a minimum of three years of formal schooling was found to be positively and significantly related to TE. ... Over all technical and apparent allocative efficiency are related to farmers' experience, literacy, and access to resources' (for Sir Lanka, Ekayanake, 1978: 515).

'Education contributes to production in several dimensions. This study found a strong indication of worker effect and allocative effect and also an indication of the 'overall' scale effect' (for Taiwan, Wu, 1977: 708).

Like the previous models the stochastic frontier models (production, cost and profit) is hardly without limitations. Apart from the philosophical questions raised by Førsund *et al* concerning the frontier models, the level of efficiency estimated by the stochastic frontier models is greatly influenced by the specification of the error term (See Førsund, *et al*, 1980; Ali and Chaudhry, 1990; and Assefa, 1995).

3.3.4. Empirical Studies on Efficiency of farmers in Ethiopia

The first study we have reviewed on the Ethiopian case is the work of Sisay (1983). Sisay used parametric linear programming method to test the hypothesis that there is a considerable potential to increase the productivity of small holders by improving their efficiency. He used data collected from four different sites in Chilalo province and concluded that there is a considerable gap between the actual and optimal resource allocation and peasant farmers can increase income and productivity under the optimal farm plans (Sisay, 1983).

Alemayehu (1989) also attempted to measure the technical and allocative efficiency of two peasant associations (PAs) in Ada and Holeta woredas. To estimate TE he fitted a Cobb-Douglas type technology. Then he tested the structural stability of the regression coefficients using Chow test and he concluded that 'these results (the significant coefficients estimated), coupled with the test for the structural stability of regression coefficients, indicate that all income groups are equally technically efficient, i.e., they face the same production function' (Alemayehu, 1989: 59). He has also tried to measure the AE of the farmers using the relation

$$K_i = \beta_i \frac{Y}{X_i} P_i \qquad [7]$$

Where

β_i *is the production function coefficient of the i^{th} input*

P_i *is the price of the i^{th} input in terms of 'teff' and Y and X_i are output and input i respectively.*

Then he tested weather K_i is equal to one or not and if this hypothesis is rejected he considered it as an allocative error. Based on such methodology and reasoning he conclude that in terms of labour use, low income groups are allocatively more efficient than high and low income group and in terms of land use all groups are allocatively inefficient since the corresponding K values are higher than one (Alemayehu, 1989). However, this method of evaluating allocative efficiency may not be correct since the error term of the production function used to estimate β includes both random factors and allocative errors.

The other latest works on these areas are the work of Assefa (1995) and Abrar (1996). Both concentrated on TE aspect of efficiency. Assefa Followed the three stage procedure to test the impact of education on TE of small holders in Ada and Baso and Worana woredas. He concluded that 'Secondary education, oxen, time of fertiliser delivery, and extension contact are the most important factors influencing technical efficiency in Ada sub district' (Assefa, 1995: 192). By using the same procedure Abrar identified differences in technical efficiency among his sampled farmers and he attributed these variations in efficiency to differences in socio-economic factors such as farm and household size, age, and the level of off-farm activities (Abrar, 1996: 7). However, since the main concern of these studies was on TE, they did not attempt to see the allocational efficiency aspect of total efficiency. Thus, this study considers additional dimensions to efficiency studies in the Ethiopian agriculture since it uses profit function approach that specifically focuses on the impact of education not only on technical but also on allocational efficiency of farmers.

4. METHOD OF THE STUDY

4.1. Sources of Data

The data used in this study is based on the Ethiopian Rural Household Survey conducted by the Department of Economics, Addis Ababa University, in collaboration with the Centre for the Study of African Economies (CSAE), Oxford University, in 1993/94. Overall, 15 Peasant Associations (PAs) were deliberately selected and covered by the rural household survey. Out of these PAs four PAs namely Adele Keke, Debre Birhan (specifically Kolomargefia), Sirbana Godit and Trufa Kechme PAs were selected for this study based on the number of households (HHs) in the PAs who used fertiliser and hired labour during the *meher* season of 1993. These PAs with all sampled households (i.e., 322 HHs) are taken to be sub-sample 1. But all of the HHs in the 4 PAs did not use these inputs, therefore, those HHs who used the above two inputs are taken separately and labelled as sub-sample 2 (120 HHs). Sub-sample 2 is used to estimate the profit and the input demand functions and then to prove the existence of efficiency differentials across farmers. It is also used to analyse the impact of education on these efficiency differentials. However, since sub-sample 2 is derived from sub-sample 1 based on some characteristics of farmers, i.e., the use of the two variable inputs, there might be a selectivity bias problem. Therefore, sub-sample 1 has been used to test the problem of selectivity bias and if it exists to correct it.

4. 2. Measurement of Variables

The variables used in the model are defined as follows:

Value of output: This is defined as the physical amount of annual crops produced in the *`meher'* (main) season of 1993/94 in kg multiplied by their respective prices. Due to lack of data, farm specific output prices are not used. Instead, output prices taken from the reports which complement the survey used.

Land: Land is measured in physical unit of cultivated area (hectares).

Total labour inputs: Man days of hired, family, and traditional (exchange) labour used in all operations i.e., ploughing, weeding and harvesting define labour inputs.

Oxen days: A direct measure of this variable does not exist in the survey. However,the survey provides labour input in to different activities. Therefore, this information has been used to define the oxen days variable.

Fertilizer: This variable is measured by adding (with out weighing) all types of fertilisers in k.g.

Education of farmers: This variable is measured in two different ways.

a) *Literacy level:* This is a qualitative variable which takes 1, if at least one permanent member of the HH can read or write or has an Adult Literacy Program Certificate [ALPC] and 0 otherwise.
b) *Primary Education*: In this case education is a dummy variable which takes 1, if any permanent member of the HH completed primary education and 0 otherwise.

Asset: This variable is defined as the sum of current values of all furniture, farm implements and other equipment (except fire arms) owned by the HH in Birr. This variable is expected to catch up the wealth position of the HH and it may also serve as a proxy to capital since the major parts of the items were farm equipments.

Soil fertility: This variable is constructed based on the judgement given by the respondents regarding the fertility of their land. For *'lem'* and *`lem teff'* land types 1 is given and zero otherwise.

Ownership of land: It takes one if the HH is the owner of the land and 0 otherwise.

Age: Age is defined as the age of the HH head in years. It is taken as a proxy for experience.

Adoption of fertiliser: If the HH uses fertiliser during the main season of the survey it takes the value 1 and 0 otherwise.

Restricted profit: Value of total output in Birr less cost of variable inputs in Birr (cost of hired labour and fertiliser). From the total labour input only hired labour is taken as a variable input mainly because other forms of labour can not be increased or decreased in the short run (see Stefanous and Saxena, 1988; Pudasaini, 1982; Bravo-Ureta and Rieger, 1991).

Hired labour: Total hired labour used in all operations in man days.

Family and traditional labour: All labour used in all operations except hired labour in man days.

Wage rate: This variable is measured by dividing the sum of total payments (in cash and in kind) for all operations by the total man days of hired labour in all operations.

Price of fertiliser per kg: It is estimated by dividing the total expenditure on fertiliser by the amount of fertiliser purchased in kg.

Pre-harvest labour cost: To sum all types of pre harvest labour inputs (i.e., hired, traditional and family), 0.75 pre harvest family and traditional labour in man days is assumed to be equivalent to 1 pre-harvest hired labour. Then the sum of all types of labour in man days in pre-harvest operations is multiplied by the wage rate to obtain the total pre harvest labour cost.

4.3. The Empirical Model

Proving the existence of TE and/or AE differences in the sampled farmers is the first task of a study of this nature; otherwise it is pointless to analyse the impact of other variables such as education on efficiency if there is no efficiency difference at all or if it is very small.

Under conventional economic theories where farmers are assumed to face the same level of input and output prices, identical technology and have equal profit maximisation motivation, efficiency differentials may not be expected. However, farmers may differ in initial fixed factors endowments (land, capital, etc.), in their farming practices (quality of plaguing, time of planting, weeding and harvesting, combination and usage of farm implements and draft animals, etc.), in their usage of different quantity and quality of purchased inputs (such as fertiliser, hired labour), in their choice of outputs to be produced, in the prices they sell and buy, etc. These differences in isolation or in combination can render efficiency (both TE and/ or AE) differentials.

To test the existence of efficiency differentials among the sampled farmers the following model was estimated using the FRONTIER Computer Program Version 4.1 (Coelli, 1994).

$$\ln \Pi_2 = \alpha_0 + \sum_{i=1}^{2} \beta_i \ln W_i + \sum_{j=1}^{3} \phi_j Z_j + U + V \qquad [1]$$

Where:

Π_2 = restricted pre harvest profit in Birr

W_1 = Wage rate in Birr

W_2 = Price of fertiliser in Birr
Z_1 = Area cultivated in hectare
Z_2 = Oxen days
Z_3 = Asset of the HH in Birr
U = Non-positive error term which shows that the profit function of each farmer must lie on or beneath the maximum feasible profit function
V = Random disturbance term which is assumed to be normally distributed
α_0, β_i, and ϕ_j = are parameters to be estimated.

Given the data and the above model the following two hypotheses were tested.

1. There is no profit inefficiency in the sampled farmers: Ho: E[U]=0
2. If there is profit inefficiency in the sampled farmers it arises by chance:

$$Ho: \gamma = \frac{\sigma_U^2}{\sigma_U^2 + \sigma_V^2} = 0$$

5. EMPIRICAL RESULTS

5.1. Efficiency Differences among the Sampled Farmers

The results of the frontier profit function analysis for the sampled farmers are presented in Table 5.1. Both the Ordinary Least Squares (OLS) and the Maximum Likelihood (ML) estimates are given for the sake of completeness. The signs of the coefficients of all variables, except for the coefficient of the wage variable which turned out to be positive in the ML estimation, are as expected. The coefficient of the wage variable has the wrong sign in the case of the ML, though insignificant, probably due to measurement error. Our main interest lies on the value U and γ. The parameter γ is the ratio of the variance of U and the sum of the variances of U and V. A higher mean value of U is an indicator of profit inefficiency. A value of γ close to 1 shows efficiency differences among the sampled farmers which is not accounted by random factors.

As is shown in Table 5.1, the mean value of U, i.e., E[U], is 46 percent and the value of γ is also 0.87 and highly significant. Technically this means that the variance of U, i.e. σ^2_U, is different from zero and the one sided specification of the error term is correct. Economically the relatively high value of E[U] indicates that on the average there was 46 percent profit inefficiency in the production of annual crops during the meher (main) season of 1993/94 in the sampled farmers. The high and significant value of γ also reveals that the nearly half profit inefficiency exhibited in the sampled farms arises not due to chance and factors outside the control of the farmers but due to mainly the divergence of the actual practice from the best farming practice.

Table 5.1: Results of the OLS and ML Estimation of the Profit Function

Variables	Parameters	Estimated Values	
		OLS	MLE
Constant	α_0	1.6412* (2.1123)	1.7017* (2.1471)
Wage	β_1	-0.0996 (0.9075)	0.0648 (0.5851)
Price of fertiliser	β_2	-1.1018** (1.2555)	-0.9956** (1.2755)
Land	ϕ_1	0.4060** (1.2699)	0.4349** (1.2584)
Oxen days	ϕ_2	0.2235** (1.3743)	0.2068** (1.4586)
Asset	ϕ_3	0.1581** (1.3278)	0.1423** (1.3354)
Log-likelihood function		-3.1321	-3.1286
$\sigma^2=\sigma^2_U+\sigma^2_V$			1.1122** (1.5214)
$\gamma = \frac{\sigma^2_U}{\sigma^2_U+\sigma^2_V}$			0.8744* (2.1316)
Mean of profit inefficiency i.e., E[U]			46%
Number of households		120	120

* significant at 1 % and ** significant at 10 %

Note: Figures in parentheses are t ratios

Source: Own Computation

Table 5.2 Distribution of Farm Specific Profit Efficiency

Level of profit efficiency	Frequency	Percent	Cumulative percent
0.00 - 0.21	7	5.8	5.8
0.21 - 0.41	20	16.7	22.5
0.41 - 0.61	47	39.2	61.7
0.61 - 0.81	40	33.3	95.0
0.81 - 1.00	6	5.0	100.0

Source: Own computation

There is also a wide variation in profit efficiency across the sampled farmers. Table 5.2 and the graph in appendix II show this wide variation. About six percent of the sampled farmers have a profit efficiency level of less than 25 percent. More than 70 percent of the farmers have an efficiency level of 60 percent. As shown in Table 5.2 the number of farmers with an efficiency level of more than 80 percent is six. The wide variation in the level of profit efficiency is a clear manifestation of the efficiency differentials between smallholder in this country.

5.2. The Impact of Education on Allocative and Technical Efficiency of Farmers

5.2.1. Selecting Estimation Methods and The Problem of Selectivity Bias

So far we have tried to show the existence of inefficiency in the sampled farmers and the hypothesis of equal profit efficiency has been rejected. Moreover, the research also indicates that the efficiency differentials are basically due to factors under the control of the farmers. This means farm specific characteristics, rather than factors which are beyond the control of the farmers, are much more responsible for the observed inefficiency. However, the observed 46 percent mean profit inefficiency may arise either from technical inefficiency, allocative inefficiency or both. In this section we analyse the impact of one farm specific characteristics, i.e. education, on allocative and technical efficiency of farmers.

The following model is specified to analyse the impact of education on efficiency differentials of educated and illiterate farmers.

$$\ln \Pi_i = \alpha_0 + \delta^L \; D^L_{ik} + \sum_{j=1}^{2} \beta_j \, lnw_{jik} + \sum_{j=1}^{2} \gamma_j \, lnZ_{jik} + \alpha_1 \, D_{ik} + \beta_{\lambda 1} \lambda_{ik} + V_{ik} \ldots [2] \qquad [2]$$

$$\frac{-W_1 X_1}{\Pi_1} = \beta^L_1 \, D^L_{ik} + \beta^I_1 \, D^I_{ik} + \beta_{\lambda 2} \lambda_{ik} + \varepsilon 1_{ik} \qquad [3]$$

$$\frac{-W_2 X_2}{\Pi_1} = \beta^L_2 \, D^L_{ik} + \beta^I_2 \, D^I_{ik} + \beta_{\lambda 3} \lambda_{ik} + \varepsilon 2_{ik} \qquad [4]$$

Where:

K is 1 or 2 based on whether education is defined as literacy level or primary education , respectively

j is the j^{th} input and i is the i^{th} household

Π_1 is restricted profit

D^L is dummy variable which takes 1 for literate farmers and 0 otherwise

D^I is dummy variable which takes 1 for an illiterate farmers and 0 otherwise

W_1 is Wage rate and W_2 is price of fertiliser

Z_1 is area cultivated in hectare and Z_2 is family and traditional labour in man days

D is soil fertility dummy

X_1 is hired labour in man days and X_2 is fertiliser in kg

λ is the inverse Mill's ratio

V is statistical errors and other exogenous factors,

ε_1 and ε_2 are statistical errors and difference between expected and realised prices respectively, and,

α_o, α_1, δ^L, $\beta_{j,}$ γ_j $\beta\lambda_j$ $\beta^L{}_i$, and $\beta^I{}_i$ are parameters to be estimated from the profit and the input demand functions.

The above equations can be estimated using OLS since the error terms of the equations are tested not to be correlated. However, in order to estimate these equations, first, we have to derive the Inverse Mill's ratio variable. Thus we use LIMDEP econometric software which takes into account the problem of selectivity bias. The results are presented in Table 5.3.

In all the functions the estimated coefficients carry the expected signs and most of the variables are significant at less than 10 percent. The sample selection parameters in all the three equations, however, are not significant. This implies that sub-sample 2 that is formed based on the adoption of fertiliser and hiring labour input can be considered as a random sample. In other words, this result shows that there is no statistically significant selectivity bias problem and equations [2], [3], and [4] can be estimated by OLS for sub-sample 2 without adding the Inverse Mill's ratio variable.

Table 5.3 Two Stage Least Squares Results of the Profit and Input Demand Functions with Correction for Selectivity Bias

Variables	TSLS Estimated Values
1. The profit function	
Constant	5.8438* (7.473)
Education 2[a]	0.34985* (1.895)***
Wage	-0.1046 (1.284)**
Price of fertiliser	-0.6235 (2.062)*
Area cultivated	0.6133 (4.010)**
Family and traditional labour	0.0726 (2.114)**
Soil fertility	0.3487 (1.938)*
Asset	0.1399 (3.088)
λ_1	0.3198 (0.855)
Model Test F[8,111]	0.75
2. The labour Demand function	
Educated 2	-0.0167 (0.137)
Illiterate 2	-0.1118 (0.648)
λ_2	-0.0570 (0.365)
Model Test F[2,117]	9.75
3. The fertiliser demand function	
Educated 2	-0.0679* (2.187)*
Illiterate 2	-0.0564 (1.295)
λ_3	-0.5738 (1.444)
Model Test F[2,117]	1.38

a) The result is also similar for literacy level variable.
*, **, *** Significant at 1%, significant at 5% and significant at 10%, respectively.
Figures in parentheses are t ratios
Source: Own computation

5.2.2. Estimated Results of the Profit and the Input Demand Functions

To analyse the impact of education on allocative and technical efficiency of farmers in the sub-sample 2, we imposed the following restrictions on the profit and on the input demand functions. Then, the Wald test statistics is used to test the validity of each restriction:

1. Educated and uneducated farmers have *equal relative economic* efficiency;
   Ho: $\delta^L = 0$

2. Educated and uneducated farmers have *equal allocative and technical* efficiencies:
   Ho: $\delta^L = 0$, $\beta^L_1 = \beta^I_1$, and $\beta^L_2 = \beta^I_2$

3. Educated and uneducated farmers have *equal relative allocative* efficiency in utilisation of hired labour and fertiliser inputs:
   Ho: $\beta^L_1 = \beta^I_1$ and $\beta^L_2 = \beta^I_2$

4. *Absolute allocation* efficiency of *educated farmers* in the utilisation of both hired labour and fertiliser inputs:
   Ho: $\beta_1 = \beta^L_1$ and $\beta_2 = \beta^L_2$

5. *Absolute allocation* efficiency of *illiterate farmers* in the utilisation of both hired and fertiliser inputs:
   Ho: $\beta_1 = \beta^I_1$ and $\beta_2 = \beta^I_2$

All the above hypotheses are tested by jointly estimating the profit and the input demand functions after the appropriate equality constraints are imposed. However, OLS is no longer useful since we have linear restrictions. Therefore, the Seemingly Unrelated Regression Estimation (SURE) is used to jointly estimate the profit and the input demand functions under the above linear restrictions.

The results of the basic model by OLS, single equation estimation, and the joint estimation of the profit and the input demand functions (with and with out incorporating each restrictions) by SURE are presented in Tables 5.4. and 5.5. The results presented in Table 5.4 are based on Model I in which the education variable is measured in terms of reading, writing and ALPC (literacy level). Table 5.5 summarises the results based on the second definition of education, i.e., completion of elementary education (primary education).

Theoretically the profit function and the corresponding input demand functions must be a non-increasing function of variable input prices. This requirement of the theory is fulfilled because β_j, the coefficients of input prices, are less than zero in both the profit and input demand functions. The coefficients of the fixed inputs are also positive and significant in accord with the requirements of the theory. Thus, the estimated profit and input demand functions satisfy the basic properties of the theoretically accepted profit and input demand functions.

Table 5.4. Joint Estimation of the Profit and the Input Demand Functions: Model 1

Parameter	Basic Models		Hypotheses				
	OLS	SURE	1	2	3	4	5
α_0	6.73* (16)	6.26* (17)	6.77* (18)	6.71* (19)	6.55* (18)	6.11* (25.9)	6.54* (26.8)
D^L	0.60* (4.0)	0.55* (3.7)	**0.00**	**0.00**	0.33* (2.5)	0.53* (3.73)	0.42* (3.0)
β_1	-0.09 (1.1)	-0.02 (0.4)	-0.66 (0.91)	-0.05 (0.6)	-0.03 (0.4)	**-0.06**** (1.7)	**-0.18*** (3.1)
β_2	-0.84* (2.7)	-0.29 (1.1)	-0.23 (0.87)	-0.23 (0.87)	-0.41 (1.5)	**-0.10* (10.8)**	-0.16* (7.1)
γ_1	0.65* (5.7)	0.53* (5.4)	0.51* (5.1)	0.51* (5.21)	0.56* (5.5)	0.54* (5.47)	0.50* (5.1)
γ_2	0.07* (2.2)	0.09* (3.0)	0.09* (3.1)	0.09* (3.14)	0.09* (2.9)	0.09* (3.3)	0.08* (2.9)
D_1	0.19 (1.8)	0.16 (1.8)	0.15*** (1.63)	0.15** (1.7)	0.17** (1.9)	0.19** (2.0)	0.18** (1.9)
β^L_1	-0.06 (1.6)	-0.06 (1.6)	-0.08* (2.1)	**-0.12*** (3.0)	**-0.11*** (3.1)	**-0.60** (1.70)**	-0.06 (1.6)
β^I_1	-0.42* (4.3)	-0.42* (4.3)	-0.32* (3.4)	**-0.12*** (3.0)	**-0.11*** (3.1)	-0.42* (4.3)	**-0.18*** (3.1)
β^L_2	-0.10* (10.6)	-0.10* (10.6)	-0.11* (11.3)	**-0.11* (12.3)**	**-0.11*** (12.7)	**-0.10* (10.8)**	-0.10 (10.6)
β^I_2	-0.17* (7.5)	-0.17* (7.6)	-0.14* (6.6)	**0.11* (12.3)**	**-0.11*** (12.7)	-0.17* (7.6)	**-0.16*** (7.1)

Bold figures show restrictions. Figures in parentheses are t ratios

* Significant at 1 percent , ** Significant at 5 percent *** Significant at 10 percent

Source : Own computation

In all of the 22 equations, (which are estimated based on the restrictions presented above) the coefficients of the education, land, and labour variables are always positive and significant. The coefficients of the variables in all of the profit functions and the input demand functions also pick the correct sign and are significant except for price variables which do not do well in some of the equations.

Table 5.5 Joint Estimation of the Profit and the Input Demand Functions: Model 2

Parameter	Basic Model (With out Restrictions)		Hypotheses				
	OLS	SURE	1	2	3	4	5
α_0	6.87* (16.0)	6.40* (18.3)	6.70* (19.1)	6.71* (19.1)	6.50* (18.2)	6.38* (29.6)	6.59* (32.7)
δ^L	0.32* (2.8)	0.32* (2.9)	**0.00**	**0.00**	0.26* (2.9)	0.32* (2.9)	0.27* (2.6)
β_1	-0.09 (1.1)	-0.00 (0.0)	-0.04 (0.5)	-0.05 (0.6)	-0.01 (0.2)	**-0.04** (0.9)	**-0,12*** (2.7)
β_2	-0.65** (2.0)	-0.18 (0.7)	-0.23 (0.9)	-0.23 (0.8)	-0.27 (1.0)	**-0.11*** (8.3)	**-0.11*** (9.2)
γ_1	0.60* (5.0)	0.50* (5.2)	0.51* (5.2)	0.51* (5.2)	0.52* (5.2)	0.50* (5.2)	0.48* (5.0)
γ_2	0.09* (2.6)	0.10* (3.5)	0.09* (3.2)	0.09* (3.1)	0.01* (3.3)	0.10* (3.6)	0.01* (3.4)
D_1	0.24** (2.1)	0.2** (2.3)	0.16*** (1.8)	0.16*** (1.7)	0.22* (2.3)	0.22* (2.4)	0.22* (2.3)
β^L_1	-0.57 (1.0)	-0.06 (1.0)	-0.01*** (1.8)	**-0.11*** (3.0)	**-0.11*** (3.0)	**-0.04** (0.9)	-0.08 (1.0)
β^I_1	-0.17* (3.2)	-0.17* (3.2)	-0.13* (2.6)	**-0.11*** (3.0)	**-0.11*** (3.0)	-0.17* (3.2)	-0.12* (2.7)
β^L_2	-0.11** (8.0)	-0.11* (8.11)	-0.12* (9.6)	**-0.11*** (12.3)	**-0.11*** (12.3)	**-0.11*** **(8.3)**	-0.11* (8.1)
β^I_2	-0.12* (9.2)	-0.12* (9.3)	-0.10* (8.8)	**-0.11*** (12.3)	**-0.11*** (12.3)	-0.12* (9.3)	**-0.11*** (9.2)

Bold figures show restrictions.
* significant at 1 per cent, ** significant at 5 per cent, and *** significant at 10 percent
Figures in parentheses are t ratios
Source : Own computation

5.2.3. The Impact of Education on Allocative and Technical Efficiency of Farmers

In this section the results of the Wald test regarding the hypotheses of equal relative allocative and technical efficiency and absolute allocative efficiency of literate and illiterate farmers are presented. Table 5.6 summarises the results of the 10 restrictions based on models 1 and 2.

Table 5.6 shows that the coefficients of D^L are statistically different from zero at less than 1 per cent level of significance. This means that the hypothesis of equal relative economic efficiency between literate and illiterate farmers can be rejected. At the same time, since the coefficients of D^L are positive and significant in all the estimated equations (see Tables 5.4 & 5.5), we can conclude that literate farmers are economically more efficient than illiterate farmers in the sub-sample 2. The rejection of hypothesis 2 also suggests that this higher economic efficiency of educated farmers emanates from their superiority in both technical and allocative efficiency.

Hypothesis 3 is also rejected in the case of Model 1. This shows that households which have at least one person who can read and write are more successful in equating the marginal value product (MVP) of hired labour and fertiliser inputs to their corresponding market prices than other households who don't have a member of a family who can read or write. This result also shows that the traditional assumption that every decision is made by the head of the HH may not be always true. The hypotheses of equal allocative efficiency can't be, however, rejected in model 2 even at 10 percent level. The rejection of this hypothesis in model 1 suggests that, for achieving relative allocative efficiency in the utilisation of hired labour and fertiliser inputs, education more than the three Rs (reading, writing and primary numeracy) may not be required.

Table 5.6 Testing of the Statistical Hypotheses: Models 1 & 2

Hypotheses	Df.	Model 1	Model 2
		Wald test (Chi-square value)	Wald test (Chi-square value)
1	1	15.07*	8.25*
2	3	10.36**	10.53*
3	2	15.20*	2.11
3.1	1	11.45*	2.10
3.2	1	8.48*	0.19
4	2	1.38	0.45
4.1	1	0.14	0.39
4.2	1	1.32	0.06
5	2	10.68*	3.70***
5.1	1	10.20*	3.36***
5.2	1	0.78	0.06

*, **, *** significance level of 1, 5, and 10 percents, respectively.
Source: Own computation

So far we have seen that educated farmers achieve higher technical and allocative efficiency than those of the uneducated ones. This does not, however, mean that educated farmers are absolutely allocative efficient. Farmers are absolute allocative efficient if they equate the marginal value product of an input to its price. Hypothesis 4 and 5 can be used to test which group of farmers are absolutely allocative efficient in utilisation of the two variable inputs. Moreover, these hypotheses help us to see whether the profit maximisation assumption we have used holds in our sample. Hypothesis 4 can not be rejected even at 20 percent level in both models. Hypothesis 5 is, however, rejected in both models at 1 percent level. These two different results reveal that the hypothesis of absolute allocation efficiency in utilisation of both hired labour and fertiliser inputs can not be rejected for educated farmers but not for illiterate ones. In other words, these results show that illiterate farmers fail to maximise profit by equating the marginal value product of hired labour and fertiliser inputs to their market prices. This result is true irrespective of the way the education variable is measured and is consistent with the rejection of equal allocative efficiency of the two groups. At the same time the insignificant Wald test value for hypothesis 4 reveals that we do not have empirical justification to reject the profit maximisation assumption.

These results are consistent with our priori expectations. In Ethiopia, where the prices of inputs and outputs were changed owing to the new economic policy and where the prices of inputs and outputs have been fluctuating very frequently, the traditional 'rule-of-thumb' decisions may no longer be a good mechanism to adjust the disequilibria created. Under such circumstances, relatively educated farmers are expected to achieve greater efficiency than uneducated farmers. This is mainly because, educated farmers are expected to acquire, analyse and evaluate various current information on different inputs and outputs much faster than illiterate farmers. Education is also supposed to increase the ability of farmers to analyse the seasonal variations in input and output prices, the quantities and qualities of inputs to be used and outputs to be produced, and to synthesise other market and technical information.

We can also see the impact of education on efficiency by combining the results given in Appendix I and Table 5.3. The coefficients of the education variable are positive and significant in both Tables. This implies that education increases not only the probability of farmers to use fertiliser and hired labour inputs but also the ability of farmers to adopt and to use these resources efficiently. This implies that education can have a dual impact. First, it increases the probability of farmers to adopt modern inputs. Secondly, it improves efficiency among the users of modern inputs by increasing their ability to choose profit maximising or cost minimising levels of inputs and outputs.

The policy implications of the above results are clear. Farmers devoid of free information and rationality assumptions are likely to make technical and/or allocative errors. According to our results educated farmers are relatively and absolutely more efficient than their uneducated counterparts, *ceteris paribus*. This implies that efficiency and consequently agricultural outputs can be increased not only by increasing the supply of inputs and improving the farming techniques as has been done in most cases, but also by increasing the efficiency of farmers through education.

6. CONCLUSIONS AND RECOMMENDATIONS

The hypothesis that 'traditional farmers are efficient but poor' has significantly changed the emphasis of policy makers for a long time. According to this theory given the available factors of production and technology, farmers can allocate their resources efficiently and consequently there is very narrow gap between the best and the actual farming practice. Therefore, agricultural output can't be increased without introducing modern inputs that change the existing traditional farming practices. As a result, considerable resources and research efforts were devoted to improve agricultural productivity through increasing agricultural investments and introducing modern technology. However, in addition to its sheer expensiveness this policy option did not achieve the desired results.

The empirical results of this study indicated that there is a considerable potential for increasing the profit efficiency of farmers using the existing factor endowments and production technology. Specifically the result suggests that at the given level of fixed and variable inputs and output prices, and farming practices, profit efficiency could be increased by 46 percent if less efficient farmers were pushed to the level of efficiency achieved by the best farmers.

The modified Y-L profit function and the various linear restrictions together with the Wald test statistics based on 120 farmers show that educated farmers are relatively technically and allocatively more efficient than illiterate farmers. The test results for absolute allocative efficiency also show that literate farmers are more successful in achieving absolute allocative efficiency than uneducated ones.

All these results clearly show that there is statistically significant profit efficiency differentials across farms and, consequently, there is a room to increase output without making major investments on modern inputs and technology. This means that the attention of policy makers should be redirected from increasing the supply of major inputs and spending much resource on research, towards improving the efficiency of farmers at the existing resources and technology. This does not, however, mean that increasing the package of modern inputs and improving the existing traditional practices through research should be neglected. The argument here is that, although increasing the supply of modern package of inputs may be necessary for increasing agricultural outputs, it is very expensive at least from the farmers' point of view and it takes relatively longer time to achieve the desired results. Improving the efficiency of farmers through better use of resources at the existing factor endowments and existing technology, however, could be a cheaper and a short-run solution to achieve higher agricultural productivity in Ethiopia where farmers are bounded with serious financial constraints. This efficiency can be achieved by raising the education level of farmers and by helping illiterate farmers to achieve the efficiency level achieved by their relatively educated neighbours.

REFERENCES

Abrar, Suleiman (1996). ***The Linkage Between Small Holder Efficiency and Sustainable Development: An Empirical Guidance***, Department of Economics, AAU, unpublished.

Aigner, D.J., C.A.K. Lovell, and P.J. Schmidt (!977) 'Formulation and Estimation of Stochastic Frontier Production Models', **Journal of Econometrics**, Vol. 6.

Alemayehu Seyoum, (1989). ***Technical and Allocative Efficiency of Farm Households in Ethiopia: Tentative Findings of A Case Study of Two PAs***, in the Proceedings of the Workshop on Problems of Rural Development in Ethiopia, IDR, AAU, 1989.

Ali, H. and M.A. Chaudhry, (1990) 'Inter-Regional Farm Efficiency in Pakistan's Punjab: A Frontier Production Study', ***Journal of Agricultural Economics***, 41(1).

Ali, M and J.C. Flinn, (1989) 'Profit Efficiency Among Basmate Rice Producers in Pakistan Punjab', ***American Journal of Agricultural Economics***, Vol. 71.

Appleton, S. & J. Mackinnon, (1993). ***Education & Health in LDCS***, Centre for the Study of African Economies, University of Oxford, Oxford.

Assefa Admassie, (1995). **Analysis of Production Technology in Crop Production, A Study of Smallholder in the Central Highlands and Ethiopia**, Ph.D. Dissertation Wissenschaftsverlag Vauk Kiel.

Bravo-Ureta, B.E and L. Rieger, (1991) 'Dairy Farm Efficiency Measurement Using Stochastic Frontiers and Neo-classical Duality', ***American Journal of Agricultural Economics***, 73(2).

Coelli,T.J, (1992) 'A Computer Program for Frontier Production Estimation: Frontier Version 2.00, **Economic Letters**, Vol. 39.

Dawson, P.J.,J. Lingard and C.H. Woodford . (1991) 'A Generalised Measure of Farm Specific Technical Efficiency', ***American Journal of Agricultural Economics***, 73 (4).

Ekayanake, S.A.B, (1987) 'Location Specificity, Settler Type and Productive Efficiency: A Study of the Mahaweli Project in Sirilanka', ***The Journal of Development Studies***, 73 (4).

Farrell, M.J.,(1957) 'The Measurement of Productive Efficiency', ***Journal of the Royal Statistical Society***, Vol. 120, Series A, Part III.

Forsund, F.R, C.A. Knox Lovell and P. Schmidt (1980) 'A Survey of Frontier Production Function and of The Relationship to Efficiency Measurements', ***Journal of Econometrics***, 13 (5).

Hill, H. & K.P. Kalirajan, (1993) 'Small Enterprise and Firm-Level Technical Efficiency in the Indonesian Garment Industry', **Applied Economics**, Vol. 25.

Kalirajan, K. (1992) 'Testing the Hypothesis of Equal Relative Economic Efficiency Using Restricted Aitken's Least Squares Estimation', ***The Journal of Development Studies***.

Kalirajan, K.P, and R.T. Shand (1989) 'A Generalised Measure of Technical Efficiency', ***Applied Economics***, 21(25).

Kalirajan, K.P, and R.T. Shand (1985) 'Types of Education and Agricultural Productivity: A Quantitative Analysis of Tamil Nadu Rice Farming', ***The Journal of Development Studies***, Vol. 21.

Kalirajan, K.P,and R.T.Sand (1992) 'Causality between Technical and Allocative Efficiencies: An Empirical Testing', ***Journal of Economic Studies***, 19(2).

Kumbhakar, S.C. (1988) 'On the Estimation of Technical and Allocative Inefficiency Using Stochastic Frontier Functions: The Case of U.S. Class 1 Rail Roads', ***International Economic Review***, Vol. 2.

Lau, L.J. and P.A. Yotopoulos (1971) 'A Test for Relative Efficiency and Application to Indian Agriculture', ***The American Economic Review***, Vol. 61.

Lockneed, M.E., Jamison, D.T. & Lau, L.J. (1980) 'Farmer Education and Farm Efficiency: A Survey, ***Economic Development and Cultural Change***, Vol. 29.

Maddala, G.S., (1992). ***Introduction to Econometrics, 2nd edition***. New York: Macmillan Publishing company.

Meeusen, W., and J. Van den Broeck, (1977) 'Efficiency Estimation From Cobb-Douglas Production Functions with Composed Error', ***International Economic Review***, Vol. 18.

Phillips, M.Joesph, (1994) 'Farmers Education and Farm efficiency: A Meta Analysis', ***Economic Development and Cultural Change***, 43(43).

Pudasaini, S.P. (1983) 'The Contribution of Education to Allocative and Technical Efficiency in Sugarcane Production in Nepal', ***Indian Journal of Agricultural Economics***, 38 (Jan/Mar).

Ram, R. (1980) 'Role of Education in Production: A Slightly New Approach', ***Quarterly Journal of Economics***, 95 (September).

Sadoulet, E. & Janvry, D. Alain, (1995). ***Quantitative Development Policy Analysis***. Baltimore: The Johns Hopkins University Press.

Saleem, S.T (1988) 'Relative Efficiency of Cotton Farms in Sudanese Irrigated Agriculture', ***World Development***, 16(8).

Schmidt, P.,and C.A.K. Lovell (1979) 'Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers' ***Journal of Econometrics***, Vol. 9.

Sisay Asefa, (1983) 'An Analysis of Resource Allocation in A House Hold Farm Economy: Cases From Chilalo Province, Ethiopia, ***Ethiopian Journal of Development Research***, vol. 5-7 (2).

Stefanou, S.E., and Saxena (1988) 'Education, Experience, and Allocative Efficiency: A Dual Approach', ***American journal of Agricultural Economics***, Vol. 70.

Umesha, K.H. (1991) 'Efficiency of Ground Nut Production in Karnataka: Frontier Profit Function Approach', ***Indian Journal of Agricultural Economics***, 46 (1).

Wlech, F., (1971) 'Education in Production', ***Journal of Political Economy***, 79 (July/August).

Yotopoulos, P.A and L.J. Lau (1973) 'A Test For Relative Economic Efficiency : Some Further Results', ***The American Economic Review***, Vol. 63.

Zellner, A., J. kementa and J.Dreze (1966) 'Specification and Estimation of Cobb Douglas Production Functions', ***Econometrica***, Vol. 34.

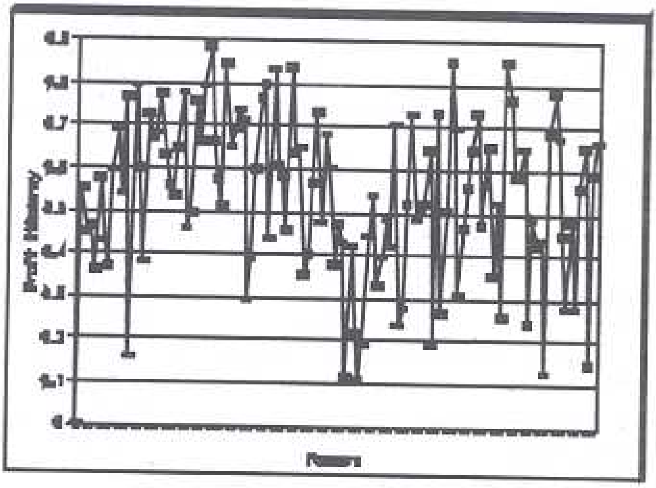
Appendix I: Probit Analysis: Determinants of Fertiliser and Hired Labour Inputs Usage

Variable	Coefficient	ML Estimated Values
1. land ownership	b_1	0.3981* (2.535)
2. soil fertility	b_2	0.6333* (4.084)
3. area cultivated	b_3	0.0089* (1.014)
4. asset	b_4	0.0003* (2.557)
5. age	b_5	(-0.0009) (0.1941)
6. education	b_6	0.54721* (3.383)
7. constant	Ao	-1.0726* (3.903)
log likelihood function Restricted log likelihood		-186.4687 -212.1693
$\text{Pseudo } R^2 = 1 - \frac{\text{loglikelihood}}{\text{restricted likelihoc}}$ 18		.40127

* Significant at 1%
Figure in parentheses are t ratios

Source: Own computation

Appendix II: Distribution of Farm Specific Profit Efficiency in Sub-sample 2



Source : Own computation

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, PP. 27-38

MEASURING INEQUALITY: AN EXPERIENCE USING INDIAN DATA

Bedassa Tadesse*

Abstract: *This paper discusses the effect of a social welfare programme initiated to mitigate absolute poverty using data collected from the Southern Indian state of Tamil Nadu. It utilised one of the modern techniques developed for measuring inequality using coefficients of Lorenz curve derived by an Ordinary Least Squares (OLS) method. The study indicates that Integrated Rural Development Programme (IRDP), in the state, has helped not only in mitigating absolute poverty but also in reducing the disparity in income distribution among the beneficiary households.*

1. INTRODUCTION

It is not uncommon to see discussions on income distribution and poverty in Ethiopia with little or no distinction made between equity and equality (see, for instance, Hadgu, 1995; IFAD, 1993; MOPED, 1993; and Solomon, 1993). Given the current market oriented economic policy of the country, measuring the disparity in asset position and income distribution will comprise the prime areas of research. This is because there are areas where policies have been made without any yardstick for measuring whether, as a result of policy action, conditions are getting better or worse (Baker, 1996: 20).

The distinction between equity and equality is based on the fundamental fact that the former is a matter of ethical judgement and thus is a subjective concept, whereas the latter is for the most part, a mathematical and/or statistical matter and thus is basically an objective one (Bronfenbrenner, 1973: 10). When we say equity with respect to income, it refers to a just distribution of income. But, justice does not necessarily mean equality. However, due to the subjective nature of equity (which has no acceptable measure) economists use measures of inequality to reflect inequity.

**Assistant Professor and Head, Department of Agricultural Economics and Extension, Jimma College of Agriculture, P. O. Box 307, Jimma, Ethiopia.. E-mail: jca.ncic@padis.org.* *The article is based on an M.Sc. thesis submitted to the Tamil Nadu Agricultural University (TNAU), India, 1996. The author would like to thank the Jimma College of Agriculture, Prof. Dr. S. Krishnamoorthy, Head, Department of Agricultural Economics (TNAU), Prof. Dr. S. Varadarajan and Amsalu Ayana. The anonymous referees of this journal have also contributed much for improving this work and thus deserve special thanks.*

It is impossible to overcome all the limitations of using Gini coefficient. Nonetheless, it would be necessary to understand them in making welfare or policy judgements based on this statistics. Various techniques have been suggested to reduce some of the shortcomings (see Gastwirth, 1972 and Pyatt *et al*, 1980). Moreover, Kakwani and Podder (1976), Kakwani (1980) and Datt and Ravellion (1992) have suggested several efficient methods of approximation which reduces the bias in Gini ratio that may arise due to aggregation by taking into account the dispersion within class intervals. With empirical justification, they have introduced a curve linear approximation of several class of Lorenz curves[1] using regression technique, from the coefficients of which the Gini ratio and relative mean deviation could be estimated by integration method. The coefficients also provide information about the dispersion of the distribution. The only drawback of this method is that it is costly in terms of the researcher or computer time as it involves mathematically complex procedures (Reimenschneider, 1983:14).

This study has the prime objective of showing how to use Gini Coefficients derived through an econometric technique. It employs the methodology suggested by Kakwani and Podder (1976) and Pyatt *et al* (1980) for estimating the Lorenz curve and thereby assess the distributional impact of major anti-poverty programmes initiated in India. It is believed that, besides the application of the method, the paper will help to assess social welfare programmes and the impact of policies that may be useful to interested researchers in Ethiopia.

2. BACKGROUND INFORMATION

India has a wide geographical area, agro-climatic diversity and abundant forest. However, with more than 70 percent of its population living in rural areas, poverty, unemployment and underemployment are common problems among the rural poor in general and weaker sections in particular. Of the 520 million poor in South Asia, 420 million (80.76%) are concentrated in India (World Bank, 1993: 20).

The mitigation of poverty has thus been the concern of planning in the country. As a result, a number of general as well as specific agricultural and rural development programmes were implemented in the country for improving the living conditions of the poor, raising their productivity levels and providing them higher employment opportunity. These include: the Grow More Food Campaign (1943), Community Development Programme (1952), Intensive

Agricultural District Programme (1961), Intensive Agricultural Area Programme (1964), HYV Programme (1966), Small Farmers Development Agency (SFDA) and Marginal Farmers and Agricultural Labourers Development Agency (MFALDA) (1971-72) etc. (Bedassa, 1996: 2-14). However, despite the growth and expansion of these programmes in size, they remained fragmented, less integrated and less comprehensive and tackled the problem of poverty from one angle or another (Grag, 1992: 5). Further, they resulted in inequalities in regional development and income which were not consistent with "Growth with social Justice" objective of the plan (Grag, 1992: 3) and hence left much of the problem of rural poverty unresolved (Lawania, 1992: 11).

As a result, the Government of India conceived a sectoral, spatial and a target integration of the on-going programmes and launched a direct attack on rural poverty by identifying all members of the target groups under the name Integrated Rural Development Programme (IRDP) in the year 1976 (Dhillon, 1992: 41). Since its inception till 1990, 34.9 million families were assisted and Rs 134,511.2 million were spent on the programme (World Bank, 1993).

The basic objective of IRDP is the creation of productive assets by way of subsidies and loans, and skill training for enabling the rural poor to generate self employment and thereby income for crossing the poverty line. At present, IRDP is one of the largest anti-poverty programmes underway in the world, with a budget of Rs 66,500 million, accounting for 18.5 percent of the Eighth Five Year (1992-97) Plan's rural development budget of India (Yojendra, 1994; 8-9).

Despite this huge expenditure, 21.68 percent of the population of rural India lives in poverty (Sen, 1981: 13) and various micro-level studies conducted over the past one and a half decades dispute whether the programme has not brought about significant reduction in poverty.

Two things, therefore, emerge: how far has the programme helped the poor to be above the poverty line and what was its distributional impact. The present paper is an effort to assess the second problem with the aim of sharing the experience of measuring the impact of such policies with social researchers in Ethiopia.

3. SAMPLING PROCEDURE AND THE DATA

As IRDP is underway in all development blocks[2] of the country, any region, district or block could be considered for the study. In this context, the Coimbatore district of the Southern

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, PP. 27-38

MEASURING INEQUALITY: AN EXPERIENCE USING INDIAN DATA

Bedassa Tadesse*

Abstract: This paper discusses the effect of a social welfare programme initiated to mitigate absolute poverty using data collected from the Southern Indian state of Tamil Nadu. It utilised one of the modern techniques developed for measuring inequality using coefficients of Lorenz curve derived by an Ordinary Least Squares (OLS) method. The study indicates that Integrated Rural Development Programme (IRDP), in the state, has helped not only in mitigating absolute poverty but also in reducing the disparity in income distribution among the beneficiary households.

1. INTRODUCTION

It is not uncommon to see discussions on income distribution and poverty in Ethiopia with little or no distinction made between equity and equality (see, for instance, Hadgu, 1995; IFAD, 1993; MOPED, 1993; and Solomon, 1993). Given the current market oriented economic policy of the country, measuring the disparity in asset position and income distribution will comprise the prime areas of research. This is because there are areas where policies have been made without any yardstick for measuring whether, as a result of policy action, conditions are getting better or worse (Baker, 1996: 20).

The distinction between equity and equality is based on the fundamental fact that the former is a matter of ethical judgement and thus is a subjective concept, whereas the latter is for the most part, a mathematical and/or statistical matter and thus is basically an objective one (Bronfenbrenner, 1973: 10). When we say equity with respect to income, it refers to a just distribution of income. But, justice does not necessarily mean equality. However, due to the subjective nature of equity (which has no acceptable measure) economists use measures of inequality to reflect inequity.

*Assistant Professor and Head, Department of Agricultural Economics and Extension, Jimma College of Agriculture, P. O. Box 307, Jimma, Ethiopia.. E-mail: jca.ncic@padis.org. *The article is based on an M.Sc. thesis submitted to the Tamil Nadu Agricultural University (TNAU), India, 1996. The author would like to thank the Jimma College of Agriculture, Prof. Dr. S. Krishnamoorthy, Head, Department of Agricultural Economics (TNAU), Prof. Dr. S. Varadarajan and Amsalu Ayana. The anonymous referees of this journal have also contributed much for improving this work and thus deserve special thanks.*

Economists have developed several yardsticks to measure the impact of policy on the distribution of income. Substantial improvements have also been made in these measures since they were formulated in the 1920s. Most common among them are various inequality measures (see Fields, 1980). The chosen measures, however, should satisfy five basic properties. These are (1) Pigou-Dalton transfer sensitivity; (2) symmetry; (3) mean independence; (4) population homogeneity and (5) decomposability (Foster, 1985).. These properties were considered desirable, although emphasis varies depending upon what the researcher wants to address, on account of the need to address issues such as: increase in poverty index as a result of the transfer of a fixed amount of money from a poor person to a rich person should be decreasing the income of the donator; rising poverty in particular subgroups could lead to an increase in total poverty index and vice versa; pooling two or more identical populations should not increase the poverty index; and, finally, a decrease in the income of the poor should increase the poverty index.

The most commonly used measure of inequality includes Theil's entropy index (T), Theil's second measure (L), the coefficient of variation (CV), Gini coefficient (G) and the Lorenz curve (LC). However, as the two Theil measures are not decomposable and the coefficient of variation is affected by extreme values, many economists have used the Lorenz curve and the Gini coefficient for measuring inequality. Further, the Gini coefficient has been used widely because it is a single statistic, conceptually easy to understand and compute. However, the usual linear approximation of Lorenz curve and Gini coefficient has the following limitations (Reimenschneider, 1983:4):

i) it is only a relative measure of income distribution and says nothing about absolute income. This leads to difficulties in comparing different groups with different levels of income.
ii) comparing distributions over a time where the universe has shifted significantly using Gini Ratio computed in the usual method introduces a bias (Benson, 1970: 446),
iii) it fails to consider the dispersion of income or benefits within each cell (interval) of the grouped data and aggregation of income receiving units. Thus, a change in the number of cells (intervals) used to group the data changes Gini coefficient (Reimenschneider, 1983: 21),
iv) the same Gini ratio can be obtained from Lorenz curves that cross each other. Thus, there is no way to determine which income class gets relatively lower or higher income shares (Reimenschneider, 1983:7), and
v) there is a problem of determining statistical differences between Gini coefficients (Reimenschneider 1983: 10) and thus direct comparison of the coefficients is inappropriate.

Indian state of Tamil Nadu was selected taking into account the logistics, accessibility and time constraint.

A two stage probability proportionate random sampling technique was adopted and 65 household beneficiaries were selected for the present study. In the first stage, Udumalpet block was selected at random from the list of beneficiaries under IRDP assistance in all sectors (primary, secondary and tertiary) during 1992/93; for the second stage, 65 households were selected at random taking the sectoral distribution into account . The year 1992/93 was selected because the beneficiaries covered by the programme were expected to cross the poverty line in two years time.

The primary data pertaining to various socio-economic characteristics of the selected households were collected using a pre-tested schedule using personal interviews. The 1995 household income[3] which was used in this analysis was arrived at through income accounting method. As each beneficiary possessed a loan book *(Vikas Patrikas)* details on loan, subsidies and repayments were easily obtained.

4. METHOD OF ANALYSIS

Three measures of income distribution pattern (inequality), namely, Lorenz curve, Gini coefficient, and relative mean deviation were computed following Kakwani (1976) using a computer programme called MSTATC. The usual method of linear approximation of Lorenz curve and Gini coefficient involves grouping the data into a number of cells. This, however, has drawbacks as discussed earlier and thus limits its application to the present situation. Therefore, using one of the approaches[4] suggested by Kakwani and Pyatt (1776), the equation of the Lorenz curve was derived and the coefficients were used to compute Gini coefficient (G) and relative mean deviation (R) that are free from some of the drawbacks.

4.1. The Econometric Model

The coefficients of the Lorenz curve at time (t) were estimated through Ordinary Least Squares (OLS)[5] method as follows:

$$LogY_t = a + \alpha \log r_t + \beta \log\left(\sqrt{2} - r_t\right) + v_t \qquad [1]$$

$r_t = (p_t + q_t)/\sqrt{2}$ $Y_t = (p_t - q_t)/\sqrt{2}$ antilog a = A

$P_i = \sum_{i=1}^{k} f_i$ $f_i = n_i/N$ $q_i = \frac{1}{Q}\sum_{i=1}^{k} X_i f_i$

$Q = \sum_{i=1}^{k-1} X_i f_i$

Where:

A, α, β > 0

i = income class interval (1,2,....k)

n_i *= number of households in income class i*

N = total Sample size

p_t *= cumulative frequency of households*

q_t *= cumulative frequency of households mean income*

X_i *= mean income of households in income class i*

v_t *= random error term*

t = time period:

1 pre IRDP (1992/93)

2 post IRDP (1995/96)

a, α, & β are parameters to be estimated. All the classical assumptions of OLS regression were made in estimating the parameters.

The values of α and β provide an insight into the nature of income distribution. If α = β, the income distribution is symmetrical, i.e., it is normal. If α > β, the Lorenz curve is skewed towards (0,0), i.e., the highest and lowest income groups receive large income share. If α < β, the Lorenz curve is skewed towards (1,1) i.e., middle income groups get the highest income.

Given the Lorenz curve equation at time t in (1), the Gini coefficient (G_t) in period t was estimated (see Kakwani, 1976:134-148).

$$G_t = \int_0^{\sqrt{2}} A(r_t)^{\alpha} (\sqrt{2} - r_t)^{\beta} \delta r_t$$

Which basically is,

$$G_t = 2A(\sqrt{2})^{1+\alpha+\beta} \beta(1+\alpha,\ 1+\beta) \qquad [2]$$

Where:

(1+α, 1+β), is a beta function and all other parameters are as defined earlier.

In the absence of Beta distribution table, the Beta function was estimated from Gamma (G) function as follows:

$$\beta(m,n) = \Gamma m \Gamma n / \Gamma mn,$$

That is,

$$\beta(1+\alpha,\ 1+\beta) = \Gamma(1+\alpha)\Gamma(1+\beta)/\Gamma\{(1+\alpha)(1+\beta)\} \qquad [3]$$

Further, another measure of inequality, relative mean deviation (R), was also estimated by using the coefficients of Lorenz curve (1) as

$$R_t = (\sqrt{2})^{1+\alpha+\beta}(A\alpha^{\alpha}\beta^{\beta})/(\alpha+\beta)^{\alpha+\beta} \qquad [4]$$

Moreover, following Pyatt *et al* (1980) an alternative Gini coefficient was computed without grouping the data into income classes so as to check the consistency of the Gini coefficient estimated from the Lorenz curve coefficients, as follows

$$G_{pt} = 2/N\mu_t(Cov\ Y_{it}\ Z_{it})$$

Where ;

N	*= total sample size*	m_t	*= mean income*
Y_{it}	*= income of household I*	Z_{it}	*= Rank of household i's income*
Cov	*= covariance*	t	*= time period*
G_{pt}	*= Gini coefficient (by Pyatt)*		

4.2. Statistical Tests Results

All statistical tests were conducted using `t' and `F' distributions at one and five percent level of significance.

The result shows that poverty is positively correlated with inequality in the distributional pattern of productive assets in general and the family income in particular. Though relative inequality cannot be avoided, its escalation can be checked (Sen, 1981: 47). Thus, the productive assets provided to the poor under social welfare programmes, like IRDP, in an attempt to alleviate absolute poverty should play a positive role in minimizing the disparity in income distribution between the poor and the non-poor. If such welfare programmes are incapable of reducing poverty, they should not aggravate the disparity among the poor themselves (for example, between the poor and the ultra poor (the destitute). If this is to take place, such programmes must be designed, taking into account the initial income position, the household resources and other socio-economic factors for determining the level of assistance to different households. This implies the ultra poor (destitute) households need to be provided with more opportunities and does of assistance than the poor if they have to cope up with the poor. IRDP takes into account these factors and thus the effect on income distribution depends on how efficiently the asset was used and the resultant income generated. This general abbreviation is substantiated using the information summarized in Table 1.

Table 1: Descriptive Statistics of some Socio Economic Characteristics of the Sample Households

	Variables	Unit	Mean	Standard
1	Base (pre assistance income)	Rs	4270.00	1584.93
2	Net income from operation of IRDP	Rs	2663.74	3627.33
3	Income from other (non IRDP) sources	Rs	3977.22	2088.55
4	Current (Post assistance total household	Rs	6640.96	2299.25
5	Family size	No.	4.35	1.36
6	Level of education	Years	3.30	4.00
7	Age of beneficiary	Years	41.14	8.74
8	Working members in the household	No	2.76	1.04
9	Value of fixed productive assets possessed	Rs	6805.38	1847.09

A summary of the means and standard deviations of some of the socio-economic characteristics of the sample households is presented in Table 1. It could be seen from the table that a beneficiary household with an average family size of 4.35 persons, of which 63.44 percent (2.76 persons) are working, was able to realize a net income of Rs 2,663.74 by operating an IRDP asset. Owing to this fact, the pre-assistance income of the household, which was Rs 4,270.00 on an average, has shifted to Rs 6,640.96 at present (Nov., 1996). Although the mean current income is above the previous poverty line of Rs 6,400.00, only 11 percent of these households have an income level above the revised poverty line of Rs 11,000 (at 1992 prices). A mean test of equality between the pre-assistance and current total household income has shown that the current household income is significantly greater (at $t_{0.99}$, df = 126). This shows that the change in the absolute income level of the beneficiary households attained due to the programme was considerable. However, this change might not be uniform across all income groups . This raises the question whether the programme enhanced or reduced the disparity in income distribution between the beneficiary households (which was the main theme of this paper). This was analyzed through Lorenz curve coefficients and the associated measures of inequality (Gini coefficient and Relative Mean Deviation) at two time periods using the base (pre-assistance) household income and post-IRDP (current total household income). The Lorenz curve coefficients and the values of the Gini coefficients and relative mean deviation at the two time periods are presented in Table 2 below.

Table 2 shows that with highly significant ($P < 0.001$) F values and 99 percent multiple coefficient of determination (R^2), the function estimated was a perfect fit. Therefore, the coefficients could be used to estimate a reliable measures of inequality. As could be seen from the coefficients of the Lorenz curve in period I, i.e., prior to availing IRDP loan, the highest share of income was received by middle income groups ($a < b$, at $t_{0.99}$, df = 12) and the Gini coefficient (G_1) and relative mean deviation (R_1) are computed to be 0.205 and 0.1476, respectively. This shows that there was a skewed income distribution even among the poor households selected. On the other hand, the Lorenz curve coefficients for post-assistance period revealed a symmetrical income distribution ($a_2 = b_2$, at $t_{0.99}$, df = 12). This shows a shift towards an egalitarian distribution of income. Consequently, the Gini coefficient and the relative mean deviation have declined by five percent to 0.193 and 0.140, respectively. Further, Gini coefficient, computed alternatively, has declined from Gp_1 = 0.203 in pre-assistance period to Gp_2 = 0.193 in the post-IRDP assistance period, revealing the consistency of the first estimate.

From the results in Tabel 2, it could be inferred that the income generated through IRDP assistance contributed in reducing the disparity in income distribution among the beneficiary households[6] . This is in line with the desired objective of 'Social Justice' which aims not only at mitigating absolute poverty but also reducing income inequality.

Table 2: OLS Estimates of the Coefficient of Lorenz Curve and Associated Values of Measures of Inequality.

Period I Pre assistance L_1 (1992/1993)		Period II Post Assistance L_2 (1995/1996)	
a_1	-0.743		-0.742
α_1	0.7664**		0.8665**
	(0.0158)		(0.1300)
β_1	0.8192**		0.8731**
	(0.0151)		(0.1630)
R^2	0.99		0.99
F_1	1503.288		2255.27**
	G_1=0.208		G_2=0.193
	R_1=0.1476		R_2=0.1400

(Figures in parentheses are standard errors)
** Significant at 0.001 percent

6. CONCLUSION AND IMPLICATIONS OF THE STUDY

It is necessary that social welfare programmes and related policy measures formulated for mitigating absolute poverty should not aggravate the disparity in income distribution among individuals and regions. In other words, maintaining a just improvement in income distribution should constitute an important component of an appropriate policy. The study has indicated that the government sponsored huge anti-poverty programme, IRDP, in India has helped not only to reduce absolute poverty levels but also contributed towards a just distribution of income among the beneficiary households. This is in line with the "growth with social justice" objective of the plan.

Given the efforts of various Non-governmental Organisations (NGOs) operating in different parts of Ethiopia, the current market oriented economic policy of the government which promotes individual efforts for investment in different sectors as well as the various regional governments initiatives to supplement these attempts, we should be cautious of the possibility of escalating disparity in income distribution among the have's and have nots as well as among regions. In the absence of any concrete report, social science researchers should assess the impacts of such situation and indicate their policy implications. This approach could therefore be considered for such studies.

NOTES

[1] Kakwani and Podder (1976) initially introduced an OLS approach and latter Kakwani (1980) formulated a Generalised Least squares method. Furthermore, Villasenor and Arnold (1989) used the General Quadratic specification while Kakwani (1990) as well as Datt and Ravellion (1992) suggested the use of parametrised Lorenz functions to understand not only poverty but also income inequality as well as the growth and redistribution effects.

[2] Block is the smallest level (unit) in the administrative structure of the Indian government.

[3] Income is defined as all earnings obtained by the household from the operation of both IRDP & non IRDP assets at current (1995) prices after deducting the cost of production.

[4] One of the referees suggested the use of the Generalised Least Squares method (GLM) suggested by Kakwani (1990). GLM is a method which involves the analysis of variance and covariances in unbalanced designs with the use of adjusted sum of squares and sequential sum of squares for observations with large standardised residuals or leverages. Thus, there must be enough data to estimate all the segments (terms) in the model. Further it requires balanced nesting. The current data, however, does not fully satisfy all the above requirements. This impaired the use of General Least square method of estimation suggested.

[5] Villasenor and Arnold (1989) claims a General Quadratic specification of the Lorenz function to have a better approximation. Nevertheless, this superiority holds when the class contains elliptical (i.e., when $a < 0$) and parabolic (i.e., when $a = 0$) Lorenz curves. On their earlier paper (1984), they have shown that for hyperbolic (i.e., when $a > 0$) Lorenz curves, OLS approximation yield true Lorenz curves. That is, they satisfy $f(x) = 1/mL''(F(x))$ conditions attributed to Gaffney and Anstis by Pakes (1981). The present paper thus, builds on the later, i.e., hyperbolic ($a > 0$) Lorenz curves. This is clearly indicated in the model specified and the resulting Lorenz curve statistics. On the other hand Datt and Ravellion (1992) have also shown that imprecision associated with the Lorenz curve estimation approaches used are unlikely to be of serious concern.

[6] Prior to the suggestion of the referees, the importance of using parameterised Lorenz functions to estimate poverty indices and break them into components of growth and redistribution (income inequality) developed by Kakwani (1990) and Datt and Ravellion (1992) for this type of study was considered. It is true that parameterisation of Lorenz curves enable the decomposition of the reduction in poverty among poor households attributable to the rise in mean income of the beneficiaries under IRDP and the decline in the disparity in income distribution. However, as the issue of decomposition was not the main theme of the present paper, those who want the details can consult the works of the author in the forthcoming issues of Journal of Rural development, India as the author has considered the same under another article. Further, Kakwani (1990), Datt and Ravellion (1992) as well as Fox and Morlay (1991) provide adequate evidences of value.

REFERENCES

Baker, R. A. (1966) 'Detection and Anticipation of Impact: The Nature of The Task', in Raymond A. Baker(ed.). ***Social Indicators***. Cambridge: Cambridge University Press.

Bedassa Tadesse (1996). ***Assessment of Integrated Rural Development Programme in Coimbatore District: An Econometric Approach***, Unpublished M.Sc. Thesis submitted to Tamil Nadu Agricultural University, India.

Benson, R. A.(1970) 'Gini Ratios: Some Considerations Affecting their Interpretations', ***American Journal Of Agricultural Economics***, 52: 444-447.

Bronfenbrenner, M. (1973) 'Equality and Equity', ***The Annals***, 409: 9-23.

Datt, G. and Ravellion, M. (1992) 'Growth and Redistribution components of Changes in Poverty Measures:

A decomposition with applications to Brazil and India in the 1980s, ***Journal of Development Economics***, 38: 275-295.

Dhillon, D. S. (1992) 'Integrated Rural Development Programme in India" in, M. Singh (ed.). ***Rural Development in India*** . New Delhi: Intellectual Publication House.

Fields, G. (1980). ***Poverty, Inequality and Development.*** New York :Cambridge University Press.

Foster, J. (1985) 'Inequality Measurement', in Payton and Young(eds.) (1985). **Proceedings of Symposia in Applied Mathematics, In Providence, RI, American Mathematics Society.**

Gastwirth, J. L. (1972) 'The estimation of the Lorenz curve and Gini Index', ***The Review of Economics and Statistics***, 54:306-316.

Grag, A. 1992. ***Working and Impact of Integrated Rural Development Programme.*** New Delhi: Deep and Deep Publications.

Hadgu Bariagaber (1995) 'The dimensions of Poverty in Ethiopia: Some Empirical Evidences' in Mulat Demeke, (eds.). ***Food Security and Poverty Alleviation in Ethiopia: Problems and Prospects.*** Addis Ababa: Agricultural Economics Society of Ethiopia.

IFAD 1993. **The State of World Rural Poverty : A Profile for Africa.**

Kakwani, N.C. (1980). ***Income Inequality and Poverty: Methods of Estimation and Policy applications.*** Oxford: Oxford University.

Kakwani, N. C. and N. Podder (1976) 'Efficient Estimation Of The Lorenz Curve And Associated Inequality Measures From Grouped Observations', ***Econometrica***, 44(1): 137-148.

Lawania, V. K. (1992).***Rural Development in India.*** New Delhi: Ashish Publishing Company,

Ministry of Planning and Economic Development (OPED) (1993), ***The Social Dimensions of Adjustment in Ethiopia: A study of Poverty Alleviation***, Addis Ababa.

Solomon Gebre (1993), ***The Conditions Of The Poor In Addis Ababa: A Social Problem Not Yet Addressed***, Addis Ababa University, Addis Ababa.

Pyatt, G., C. N. Chen and J. Fei (1980) 'The Distribution Of Income By Factor Components', ***Quarterly Journal of Economics***, 95 (3): 451-73.

Reimenschneider, C. H. (1983), ***The Use Of Gini Ratio In Measuring Distributional Impacts,*** Michigan State University Press, Technical Paper 16.

World Bank (1993). ***World Development Report.*** Washington, D. C.: Oxford University Press..

Yojendra, N. D. (1994) 'Rural Development: A Challenge for the Nineties" in .) D. K. Das (ed) (1994). '***Dynamics of Rural Development.*** New Delhi: Deep and Deep Publications.

Sen, Amartya (1981). ***Poverty And Famines: An Essay On Entitlement And Deprivation***. Oxford: Oxford University Press.

_______, (1996) 'Plan Panel Releases Poverty Estimates', *The Hindu*, January 6,1996, P.13

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, PP. 39-61

AN ANALYSIS OF THE EXTENT AND CAUSES OF THE TECHNICAL EFFICIENCY OF FARMERS GROWING CEREALS IN ETHIOPIA: EVIDENCE FROM THREE REGIONS

Andre Croppenstedt and Abbi Mamo*

ABSTRACT: Technical inefficiency (TI) indicates that output gains may be possible in the short term. A study on the main determinants of technical efficiency (TE) provides valuable information to policy makers and indicates ways of formulating appropriate strategies of agricultural development. This paper measures the degree of technical efficiency of farmers growing cereals in five of the sites (Adaa, Daramalo, Kersa, Shashemene and Yetmen) covered by the Ethiopian Rural Household Survey. Using the approach developed by Aigner, Lovell and Schmidt (1977), we estimated a stochastic frontier production function using MLE (Maximum Likelihood Estimation) and COLS (Corrected Ordinary Least Squares). Due to its popularity in applied work on agriculture, we chose the Cobb-Douglas (C-D) technology. Our results show that land quality and the average age of household members engaged in agriculture are important variables in explaining output variation among farmers. In addition, regional differences are large and highly significant. With regard to causes of TE, we note that sharecroppers are, on average, more efficient. Since, within the group of sharecroppers there is much variation a more detailed study is required to shed light on this finding.

1. INTRODUCTION

For Sub-Saharan Africa, the productivity of both land and labor declined between 1973 and 1984. There are various reasons for this: policy problems, and farm level inefficiencies are few among many.

According to Hayami and Ruttan (1984) and Timmer (1988), differences in agricultural productivity can stem from a variety of factors:

1. Different endowment of internal resources, such as land and livestock;
2. Different use of technical inputs, such as fertilizers and mechanical devices;
3. Different investment in human capital through general and technical education and

* *Research officer, The Centre for the Study of African Economies, Oxford University; and Lecturer, Department of Economics, Addis Ababa University, respectively.*

4. Different size of farms, which might generate economies and diseconomies of scale.

Ethiopian agriculture is stagnating in both measures of agricultural productivity viz. land and labor productivity. Ethiopia's agricultural sector is unable to meet one of its most basic and important functions: the provision of food for the large and rapidly expanding population. Agricultural growth averaged 2.2% during the 1960s, but dropped to 0.7% in the 1970s and a mere 0.5% in the 1980s. Crop yields have stagnated at about 1 ton per hectare since the early 1970s. With the doubling of the population between 1970 and 1990, the per capita food production has sharply declined and the country has become increasingly dependent on food aid in recent years.

Agriculture today is at the heart of the Ethiopian government's drive to improve the livelihood of the rural population. Part of the on-going debate on how to transform agriculture focuses on improved technology, input levels and credit allocation. While such objectives are imperative, it is also of considerable interest to understand how far the farmers are from the production frontier in the first place (or in the jargon, what the level of technical efficiency (TE) is[1]). The reasons for this interest are: i) TI indicates that output gains may be possible in the short term, and; ii) credit for the purpose of adoption of new technologies and higher input levels will be more successful (and depending on the degree of TI perhaps substantially so) the more efficient farmers are.

The arguments for points i) and ii) above are as follows: consider that there are two farmers, A and B. Both use the same level of inputs (both fixed and variable) and both face identical production environments[2], but they do not achieve the same output levels. If farmer A achieves less output than B then we term A as technically inefficient, relative to farmer B. With regard to point i), if we can understand what drives this difference in TE, then farmer A's output could be raised without any increase in inputs. If, for example, it is lack of information that accounts for the discrepancy it is likely that output gains could be attained in a relatively short time period. While the actual story is bound to be more complex it will still be true that certain policies which are (relative to, for example, providing credit or subsidized fertilizer) less costly and may generate short term gains.

With regard to point two above , if both farmers obtain credit so as to acquire improved seeds, oxen and/or fertilizer then it is likely that farmer B will still outperform farmer A. In this sense the effect of the attempted transformation will be dampened and some (additional) resources will be wasted.

A decline in agricultural production can be caused by a sub-optimal utilization of the existing technology or due to technical inefficiency. A study on the main determinants of TE provides valuable information to policy makers and they can adopt the appropriate strategies of agricultural development.

Ethiopian farmers suffer from a lack of basic inputs such as credit, fertilizers, land and so on. The scarcity of inputs serves as a strong motivation to farmers to make the best use of the available inputs. But how? Studies that focus on indicating how effectively inputs can be put in to production to gain the maximum benefit out of them are greatly required.

In the first part of this paper, we will measure the degree of technical efficiency of cereal growing farmers in five of the sites covered by the Ethiopian Rural Household Survey. We note that work on this topic on Ethiopia is rare. In the second part we provide a discussion of the concept of the frontier production function which is a popular tool to measure TE. In the third part, the estimation of such a model is described. The data is presented in part four and results are given in part five. Part six concludes the paper.

2. THE MODEL

The modeling and estimation of frontier production functions has been an important area of econometric research during the last two decades. The seminal paper which has provided the stimulus to this research was that by Farrell (1957). However, the concept did not become widely used until: i) the stochastic frontier production function was introduced in 1977, and ii) it became possible to solve for individual technical efficiency in 1982. Following these advances this methodology has found application in a wide variety of areas such as agriculture, industry, health care, and banking, to mention but a few.

Below we give a brief survey of the concepts. For more detail see the surveys by Forsund, Lovell and Schmidt (1980), Schmidt (1985), Fare, Grosskopf and Lovell (1985), Bauer (1990), and Lovell (1993). Battese (1992) is a survey with special reference to agriculture. In our exposition we discuss only statistical parametric methods. We do not attempt to cover the topic of Data Envelopment Analysis (DEA) which has also become a widely used method.[3]

2.1 Deterministic Frontiers

Initially the discussion revolved around deterministic frontiers. A deterministic frontier is defined by :

$$y_i = f(x_i, \beta_k)e^{-u_i} \qquad [1]$$

where y_i denotes the actual output level; x_i is a vector of inputs; β_k is a vector of k parameters; u_i is a one-sided, non-negative, random variable associated with farm-specific factors which keeps the farm from attaining maximum output; and the subscript i denotes the ith farm.

The term $\exp(-u_i)$ lies between 0 and 1 and gives a measure of technical efficiency. To show this, we may write (1) as:

$$\frac{y_i}{f(x_i, \beta_k)} = e^{-u_i} \qquad [2]$$

such that $\exp(-u_i)$ is the ratio of actual to potential output.[4] Once an actual functional form has been imposed on (2) the equation may be estimated by OLS or MLE.

It has been shown that OLS provides consistent estimates of all the parameters except for the constant term. This must then be corrected by subtracting the mean of u[5]. Unfortunately, after correcting the constant term, some of the residuals may still be negative. A simpler technique is to subtract the largest positive residual from the constant term (also yielding a consistent estimate[6]). This generates one farm with u=0, i.e. exp(-u)=1, (or multiplied by 100=100% technically efficient). It is this farm which defines the maximum possible output for the given technology and sample. The rest of the sample is termed inefficient relative to this farm.[7]

To estimate a deterministic frontier by MLE one must first make a distributional assumption about u. It is important to note here that the range of the dependent variable depends on the parameters to be estimated. Hence, one of the regularity conditions used to show that MLE is consistent and asymptotically efficient is violated (see Greene 1980b). This means that the half-normal and exponential distibutions cannot be used. Greene shows that the gamma density has the desired properties, and is therefore useful.

An important drawback of deterministic frontiers is that all the deviation from the frontier is labeled as technical inefficiency. This is unrealistic (and now unnecessary) and we turn to a discussion of the more popular stochastic frontiers.

2.2 Stochastic Frontiers

In an independent work Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) suggested to allow for some random variation across the frontier. The essential idea behind the stochastic frontier model is that the error term is composed of two parts. A symmetric component (which we will always denote by v) permits random variation of the frontier across production units. It captures measurement error, other statistical noise and random shocks outside the control of the production unit. A one-sided component (which we will denote by u) captures the effects of inefficiency relative to the stochastic frontiers.

This model is written as:

$$y_i = f(x_i, \beta_k)e^{v_i - u_i} \qquad [3]$$

where $f(x_i, \beta_k)$ is the deterministic kernel; and $f(x_i, \beta_k)\exp(v_i)$ is the stochastic frontier. Technical efficiency relative to the stochastic production frontier is captured by the one-sided error component, $\exp(-u_i)$. Such a stochastic production frontier may be estimated by COLS or MLE[8]. Whichever estimation technique is used, the distribution of u_i must first be specified.

Initially, only average estimates of u were derivable. It was not until the contribution by Jondrow, Lovell, Materov and Schmidt (1982) that it is possible to derive farm-by-farm estimates of technical efficiency from the stochastic frontier estimates. Jondrow *et al* (1982) suggest to use the information contained in e_i (where $e_i=v_i-u_i$) to obtain an estimate of u_i[9] (Details about this are given in the section on estimation.) Following this development, this approach became exceedingly popular in the empirical literature.

2.3 Developments

While we do not attempt to provide a through survey of the subject, we believe it is useful to identify several important developments on the topic of technical efficiency.

Initially extensions of the basic model focused on generating more flexibility in the distributional assumptions made about u_i. Stevenson (1980) suggested a generalized stochastic frontier model where the assumption of a zero mean of u_i is relaxed. Greene (1980a) relaxed the assumption of a Cobb-Douglas technology by introducing a flexible functional form. Beckers and Hammond (1987) and Greene (1990) modeled the one-sided error term using the gamma distribution.

Following the formulation of the stochastic frontier, there came the simultaneous estimation of allocative and technical efficiency. Initially Schmidt and Lovell (1979) formulated this problem in a cost minimizing setting. Kumbhakar (1987) modeled technical and allocative efficiency in a profit maximizing framework.

Much of the recent work is focusing on applying panel data in estimating technical efficiency. This is particularly interesting in that it is then no longer necessary to make a distributional assumption for u_i.

The following paragraph gives a review of some technical efficiency studies on Ethiopian farmers. An attempt is made to indicate the methods used and the results obtained by those studies.

Assefa and Heidhues (1996) made an analysis of production efficiency of small holders in the Central Highlands of Ethiopia. They fitted a Cobb-Douglas stochastic frontier production function to cross-sectional data collected on 192 farm households. The reported results indicate that human labor, animal track power and fertilizer are the most important factors affecting productivity.

Using the first round data of the Ethiopian Rural Household Survey of 1993, Mulat and Croppenstedt (1997) adopted a mixed fixed-random coefficients regression model to estimate farm and input-specific measures of TE. In their analysis 342 farm households that practice ox-plough cultivation of cereals are incorporated. They found that human capital, such as literacy and experience are important productivity increasing variables. In addition, a high degree of farm-specific technical inefficiency is observed. Time spent collecting fuelwood and adverse events for livestock were found to be affecting TE.

Abrar (1995) applied Data Envelopment Analysis (DEA) for measuring the efficiency of small holders in three villages of Ethiopia. He used the first round data of the Ethiopian Rural Household Survey. His results show that farmers are more technically inefficient than scale inefficient.

With reference to Eastern Africa we note that work on this topic is rare. Aguilar and Bigsten (1994) use a deterministic frontier model to analyze efficiency differences of small-holder farmers in Kenya. Shapiro and Mueller (1977) considered the sources of technical efficiency of cotton farmers in Tanzania, using a deterministic frontier mode. For some preliminary work on Ethiopian agriculture see Dejene, Croppenstedt and Mulat (1994) and Croppenstedt and Mulat (1994)[10].

3. ESTIMATION OF THE MODEL

In this paper, we followed the approach developed by Aigner, Lovell and Schmidt (1977). The stochastic frontier production function is given as:

$$y_i = f(x_i, \beta_k)\exp(e_i) \qquad [4]$$

where y_i is output; the x_i are a vector of inputs; e_i is our composed error term, composed of the two terms v_i and u_i; and the subscript i refers to the ith farm.

Apart from making a distributional assumption for the error term u, we also need to impose a functional form for the production function. Our choice of the Cobb-Douglas (C-D) technology is guided by two facts: i) it has been very popular in applied work on agriculture in developing countries, and hence our results can easily be compared with previous studies; ii) it fits well even for smaller data sets[11].

Substituting the C-D functional form into equation (4) we obtain:

$$y_i = \beta_0 \prod_k x_{ki}^{\beta_k} e^{v_i - u_i} \qquad [5]$$

where: the y, x, v, u and the subscripts are as described above.

Upon transformation into logarithms we can use either COLS or MLE techniques to estimate (5). We use the latter technique as we can estimate the constant term σ^2 and λ (see below) together and, hence, improve the efficiency of the estimates[12]. To use MLE we need to make a distributional assumption for the two components, v and u. The term v is always assumed to be independently and identically distributed (iid) as $N(0, \sigma_v^2)$. For the u term the most popular choice has been the half-normal distribution i.e. u is distributed iid $|N(0, \sigma_u^2)|$.[13] We adopt this specification because it is easy to implement and the results lend themselves more readily for comparison.

The resulting log-likelihood function is written as:

$$\ln L = \frac{-N}{2}\ln\left(\frac{2}{\pi}\right) - N\ln\sigma + \sum_{i=1}^{N}\ln[1 - F(e_i\lambda\sigma^{-1}] - \frac{1}{2\sigma^2}\sum_{i=1}^{N}e_i^2 \qquad [6]$$

where:

F(.) is the cumulative distribution of the standard normal evaluated at $e\lambda/\sigma$*;* $\sigma^2 = \sigma_u^2 + \sigma_v^2$; and $\lambda = \sigma_u/\sigma_v$.

Farm-by farm level estimates of u may be obtained using Jondrow et al's suggestion of using the conditional distribution of u, given e. The mean of this distribution can be used as a point estimate of u:

$$E[u_i \mid e_i] = \sigma^*[\frac{f(e\lambda/\sigma)}{1 - F(e\lambda/\sigma)} - \frac{e\lambda}{\sigma}] \qquad [7]$$

where: $\sigma^* = \sigma_u\sigma_v/\sigma$.

For completeness we briefly outline estimation when using the COLS approach. We first run OLS on (5). The resulting residuals are then used to obtain estimates of σ_u^2 and σ_v^2 from the second and third moments of the error term. The formulas, derived in Greene (1982) are:

$$\hat{\sigma}_u^2 = \left[\sqrt{\frac{\Pi}{2}}\left(\frac{\Pi}{\Pi - 4}\right)\left(\sum_i\left(\frac{e_i}{N}\right)^3\right)\right]^{2/3} \qquad [8]$$

$$\hat{\sigma}_v^2 = \sum_i \frac{e_i^2}{N}\left(N - \left(\frac{\pi - 2}{\pi}\right)\hat{\sigma}_u^2\right) \qquad [9]$$

Where: N denotes the number of observations. The constant term is corrected by subtracting $-\sqrt{2/\Pi}\ \sigma_u$

Table 1 Site Specific Characteristics

Characteristic	Adaa	Daramalo	Kersa	Shashemene	Yetmen
Climate	Woyena Dega a	Kola b	Woyena Dega	Woyena Dega	Woyena Dega
Dominant Crop	Cereals	Cereals	Cash Crops (Chat & Cereal)	Cereals	Cereals
Households	98	74	98	102	61
Use of Fertiliser	Common	Common (Irrigation)	Common	Common	Common
Status of Farmers	Rich	Poor	Rich	Rich	Moderately Rich
Soil Erosion	No	No	Yes-Not serious	No	No
Terrain	Flat	Flat	Flat	Flat/Hills	Flat
Farming Technology	Ox Plough	Ox Plough/ Irrigation	Ox Plough	Ox Plough	Ox Plough
Landless Households c	13	3	7	1	3
Female Headed households c	23	3	24	17	10

a) Woyena Dega is used to represent a mild weather which is neither very hot nor very cold.

b) Kola is used to represent a hot climate, i.e. arid. (c) Number in survey.

4. THE DATA

In this study we use data on cereal[14] growing farmers in five of the sites covered by the first round (1993/94) of the Ethiopian Rural Household Survey (ERHS)[15]. Further disaggregation is not possible as inputs are given only as aggregates. The five sites are Shashemene, Kersa, Daramalo, Yetmen and Adaa. Shashemene, Kersa and Adaa all lie in Region 4, while Yetmen is in Region 3 and Daramalo in Region 9. For some sites specific characteristics, see table 1. In all we have information on 431 households, but various selection criteria mean that we end up with a final sample of 249 households.[16] A description of the variables used is given below:

Y	Total value of grain output in Meher season, in Birr.
A	Land cultivated under grain crops in Meher season, in Hectares
L	Total number of person days used for ploughing and weeding.
F	Amount of fertilizer applied, in Kilograms.
OX	Number of Oxen and Bulls owned by the household.
LQ	Average quality of the land cultivated, 1-3, 1 being the best quality.
AVAGE	Average age of household members whose main economic activity is farming.
PRIND	A price index computed as the weighted[17] average of the output prices.

Table 2 gives some descriptive statistics of the variables.

Table 2: Descriptive Statistics

Variable	Range	Mean	Std. Deviation
Y	202.20 - 5326.75	1498.67	1101.92
A	0.06 - 11.00	1.38	1.08
L	8.00 - 744.00	124.85	135.27
OX	0 - 5	0.95	1.12
F	0.00 - 500.00	79.91	91.78
LQ	1 - 3	1.55	0.60
AVAGE	17.50 - 64.00	31.32	8.57

5. Estimation and the Results

5.1 Estimation

The production function that we estimated is:

$$\ln\left({y_i}/{PRIND} \right) = \beta_0 + \beta_A \ln(A_i) + \beta_L \ln(L_i) + \beta_F \ln(F_i) + \beta_{ox} \ln(OX_i) + \beta_{LQ} LQ_i + \beta_{AVAGE} \ln(AVAGE_i) + \beta_6 REG3 + \beta_7 REG9 + v_i - u_i \qquad [10]$$

Where REG3 and REG9 are dummies for Region 3 and 9. The other variables are as described in section IV.

We note that for some of the independent variables (F and OX) we had some zero values. To allow for this we added 1 to these variables before transforming them into logarithms.

A priori we expected that Labor, Oxen and Fertilizer should be endogenous variables. This would lead to biased estimates of the coefficients of the model. To correct for this problem we used a two stage procedure. In the first stage we obtained predicted values of the endogenous variables by regressing them on the exogenous variables in the system.[18] We used an omitted-variable test to test for endogeneity of the three variables. Results suggest that while Fertilizer is endogenous, we can reject the hypothesis that Labor and Oxen are endogenous. Consequently, we proceeded treating only Fertilizer as endogenous, and used the predicted value of this variable in the final estimation, i.e. the second stage.

The ML estimates are given in Table 3. We note that we present the t-ratios obtained by using the heteroscedastically consistent covariance matrix. The difference to the standard covariance matrix is only small. We nevertheless conducted a more formal analysis of heteroscedasticity. First, we conducted a White test[19] and the test statistic is calculated as $N^*R^2 = 33.964$ (N is the number of observations). The critical value of the Chi-square with 26 degrees of freedom is 38.89 at the 95% level so we can accept the null hypothesis of homscedasticity. We further conducted a variable by variable analysis. This consisted of testing the significance of the coefficients in the following relationships:

$$\mathrm{var}(e_i) = \sigma^2(\alpha * z)^2 \qquad [11]$$

$$\mathrm{var}(e_i) = \sigma^2 e^{\alpha * z} \qquad [12]$$

where z represents A, L, F, OX, LQ and AVAGE, which are in turn substituted into the expressions. We did not find a significant relationship in any case.

Table 3: MLE Estimates of the Cobb-Douglas, Stochastic Frontier Production Function

Variable	Coefficient	T-ratios Absolute Values
CONSTANT	7.3684	17.884*
ln(A)	0.4289	7.152*
ln(L)	0.0757	2.263**
ln(F+1)	0.1241	4.175*
ln(OX+1)	0.0742	1.367
LQ	-0.1073	2.030**
ln(AVAGE)	-0.2270	2.089**
REG3	-0.3408	4.286*
REG9	-1.3456	8.870*
σ^2	0.2986	4.055*
λ	1.1880	2.284**

Value of log-likelihood:-144.10;Value of restricted log-likelihood:-309.30;
Chi-square based on LR test: 330.40
* and ** denote statistical significance at 1 and 5 % levels respectively

The relatively strong response of output to fertilizer use is an interesting result. It has largest effect of all the variable inputs, and contributes most to R^2 after the land variable. We calculated an elasticity of output with respect to land quality of 17% (evaluated at the mean LQ). This implies quite large gains in output for increments to land quality. For example, a farmer who has land with mean quality 1.55 and who manages to gain access to land of mean quality 2 would be able to obtain a 5% increase in output. Further, we noted that the age structure, of those whose main activity is farming, affects the productivity of the household. The main effect of including AVAGE is on the constant term, as well as a less pronounced effect on L. The regional effects are clearly very important and also very large. Particularly, Daramalo has a substantially lower intercept than other sites. The value of λ indicates that neither disturbance is dominating the error term.

5.2 The Technical Efficiency Scores

We used the result in equation (8) to obtain an estimate of the measure of technical efficiency. The frequency distribution, the range and the average level of technical efficiency is given in Table 4. All figures are in percentages, i.e. the average TE is 72% which means that farmers are, on average, operating 28% below the frontier. The results in Table 4 show that the vast majority of farmers are between 60 and 90 percent efficient. It is clear that, although relatively few farmers fall below 60% TE, large gains in output could be obtained by increasing TE. For most farmers farm output is the main source of income. Hence, for instance, a 40 to 10% increase in output would have substantial welfare gains. For example, the average income from cereals in our sample is 1498.67 Birr. A 28% increase would imply approximately 420 Birr more income from the sale of crops, with the same input levels.

Table 4: Technical Efficiency, Frequency, Range and Mean

Frequency Range	Number of Observations
30-39%	1
40-49%	8
50-59%	24
60-69%	51
70-79%	103
80-89%	61
90-100%	1
Range	32-92%
Average TE	72%

5.3 Determinants of Technical Efficiency

While identifying a large shortfall in potential output is interesting in itself, for policy purposes it is crucial to isolate some of the determinants of TE. For this reson we use the estimated technical efficiency index as the dependent variable in the second stage regression. Annex 1 gives a description of the variables we used in this part of the analysis.[20]

The variables are selected to capture various effects: i) Household characteristics and assets; ii) Acts of nature that may affect farm performance; iii) Market participation; iv) Sharecropping; and v) Access to credit.

To start with, we considered the simple correlation coefficients between the variables listed above and our index of TE. These correlation coefficients and their level of significance are given in Table 5. Only those significant at least at the 10% level are listed. None of these variables show a strong correlation with TE. It is noteworthy that the three strongest effects are due to market participation, plough ownership and sharecropping. The latter has a positive correlation coefficient that might be considered a surprising result.

Table 5: Simple Correlation Coefficients Between TE and Some Determinants

Variable	Correlation Coefficient	Significance Level
PLOUGH	0.150	0.009
OFY	-0.095	0.069
MAACT	0.194	0.001
LABH	0.097	0.064
WS	-0.114	0.036
OXTIM	-0.128	0.022
FRASHLA	0.144	0.011

See Annex 1 for the definition of variables

We then, regressed our TE index on these variables using a censored regression technique, i.e., a tobit model. This procedure is appropriate as the TE index has upper and lower bounds of 1 and 0, respectively. Dropping (step-wise) those variables with a t-ratio of less than 1 we arrived at the final results given in Table 6. We find that household assets, participation in the output market, sharecropping, and a dummy for lazy and careless farmers are the only factors that come out as statistically significant.

Table 6: Censored Regression Estimates of Determinants of Technical Efficiency

Variable	Coefficient	t-ratio
CONSTANT	0.6768	40.377*
WS	-0.0155	-1.232
LN(PLOUGH)	0.0391	2.428**
MAACT	0.0343	2.246**
FRASHLA	0.0468	1.979**
DU220	-0.0613	-2.936**

Sharecroppers (63 in total) had a mean cultivated land area of 1.68 hectare as compared to 1.28 for the rest (a difference significant at the 1% level). The average number of oxen and bulls owned is the same (0.97 for sharecroppers to 0.95 for non-sharecroppers) as is the average number of ploughs owned (1.08 to 1.17). However, sharecroppers have smaller number of family members (5.81 to 6.95: significant at the 5% level). On the input side, we found that sharecroppers use substantially more fertilizer per hectare (70.80 as compared to 54.82 Kg/Ha for the overall average: significant at the 5% level) but also substantially less labor per hectare for weeding (31.1 to 63.1: significant at the 1% level). There is no difference in the amount of labor per hectare for ploughing and harvesting for the two groups.

Some information may also be obtained by comparing the 20% least efficient farmers to the 20% most efficient farmers. As indicated in Table 7 below only Fertilizer per hectare, the number of ploughs and the fraction of total land that is sharecropped had statistically significant different mean values in the two groups. We note that the average area of land cultivated and the average number of oxen and bulls owned is practically the same in the two groups. We also looked at the share cropping and non-share cropping farmers in the top 20 group. Here we found that sharecroppers had fewer persons per household and used more fertilizer per hectare (non-sharecroppers using about the average fertilizer per hectare). Moreover, non-sharecroppers use more labor for ploughing (68 to 36), weeding (70 to 23) and harvesting (67 to 36) (in all cases per hectare). Sharecroppers have a 20% chance of not obtaining oxen at the right time, while non-sharecroppers have a 50% chance. We note that no sharecroppers obtain any income from off-farm activity, which is not the case for non-sharecroppers.

Table 7: Comparison of Group Means: Top 20% to Bottom 20% Technically Efficient Farmers

Variable	Bottom 20%	Top 20%	t-value
F/A	39.27	63.79	3.19*
PLOUG	0.82	1.38	3.20*
FRASHLA	0.082	0.241	2.53**

To look at the problem from another angle we compared the sharecroppers that are in the top 30% efficient group to those that are in the bottom 30% efficient group. The only significant difference between these two groups appears to be fertilizer per hectare (80.05 to 50.41). Fertilizer is clearly not used uniformly and is used more intensively by the sharecroppers. Indeed 12 of the 63 sharecroppers use no fertilizer.

It seems arguable that factor endowments do not determine a family's access to land. Some sharecroppers are more efficient on average but this cannot be a general explanation of access to land either. In the top 20 group they do not reach the highest value of output per hectare. Indeed sharecroppers in the top 20 obtain 1661 Birr per hectare on average, while non-sharecroppers in this group obtain 2372 Birr per hectare (a difference significant at the 5% level). While their technical efficiency scores are very similar their average yields per hectare are not. Further, most sharecroppers fall outside of the top 20 group (two thirds, with 15% of them in the bottom 20 group). What the evidence suggests is that sharecroppers are a fairly heterogeneous group in terms of efficiency and input levels. It would seem useful, but beyond the scope of this article, to look into: i) the landlord tenant relationship, and; ii) the position of the tenant in the village, i.e., looking for wealth and power as possible explanatory variable. We also note that sharecroppers from the different sites also have different efficiency scores (see Table 9). Clearly a more disaggregated analysis is necessary to capture the intra-site differences in sharecropping contracts and perhaps the social structure.

Table 8: Technical Efficiency Scores (in percent) for Share croppers and Non-Share Croppers by Site

Site (Region)	TE score on non-Sharecroppers	TE scores of Sharecroppers (number)
Yetmen (3)	72	75(24)
Shashemene (4)	72	76(26)
Daramalo (9)	73	69(5)
Kersa (4)	73	69(2)
Adaa (4)	72	76(6)

Finally, we give some groupings of the two categories relative to the dummy variables. Table 9 shows that the differences in efficiency between the two groups are not attributable to natural environment variables as captured by RAIN, DURHA, WS, FW, BOA, etc. Nor is access to credit any different in the two groups (very low in either case). Important factors appear to be access to land (DUSCR), oxen (OXTIM), and whether the farmers participate in the market (MAACT) and whether the farmer or family members were too ill to work at an important time (ILL). The level of education of the head of the household (EDHHH) does not appear to be significant.

The coefficient obtained for the variable OXTIM shows that the oxen market is not well developed and that timely and adequate use may hinge on the household being adequately endowed with these factors in the first place. If not, output will suffer. MAACT suggests that those farmers that are more integrated into the market are also more efficient. 195 farmers out of the 249 did operate in the market. It is possible that this variable captures the relative wealth of the two groups, with farmers not operating in the market being in the poorer section.[21] We note that another explanation is that MAACT might be a proxy for access to market, i.e., access to transport and roads.

Table 9: Comparison of Top 20% to Bottom 20% by Various Categories

Variable	Percent of Bottom 20% Falling into Dummy=0 Category	Percent of Top 20% Falling into Dummy=1 Category
DUFEHHH	8	4
DUALP	24	26
EDHHH	14	10
DUOX	24	28
RAIN	16	11
DURHA	34	36
WS	50	40
FW	16	26
BOA	48	44
WDAM	26	26
OXHM	66	38
LAHM	22	18
ILL	32	16
LOAN1	2	0
LOAN2	10	10
LOAN3	6	2
LOAN4	0	0
MAACT	60	84
DUSCR	18	40

6. CONCLUSION

In this paper we estimated a production function for cereal producing farmers in three regions of Ethiopia. Our results show that land-quality and the average age of household members engaged in agriculture are important variables in explaining output variation among farmers. Further regional differences are large and highly significant.

We found that the average level of technical efficiency was only 72%, i.e., that output could be 28% higher with the same level of inputs. Only one farm achieved more than 90% TE. Clearly the output gains by improving efficiency and without additional inputs are very large indeed. The welfare implications for farmers are likewise very high (we compute a gain of 420 Birr at the average value of cereal output, given a 28% increase in TE).

With regard to causes of technical efficiency, we noted that sharecroppers are, on average, more efficient. However, within the group of sharecroppers there is much variation and more detailed study of this problem is required to shed light on this finding. Market integration, as measured by market participation is also positively correlated with technical efficiency. We note that this variable may capture the relative poverty of the farmers as well as the distance from the market. Finally, some of the variations in efficiency are explained by work effort. About 9% of the farmers are classified by their peers as lazy and they are 6% less technically efficient than the average.

NOTES

1 . We use TE and TI as abbreviations for technical efficiency and technical inefficiency respectively.

2 . We assumed that there are no exogenous shocks, or if there are, they affect both farmers in the same way. That is, we rule out luck as accounting for output differences.

3 . Especially in situations where imposing a particular functional form may be inappropriate a bibliography on the topic of efficiency (technical, allocative and some related topics) is available from the authors on request.

4 . We multiply the efficiency score by 100 and get a percentage measure of TE.

5 . This method was developed by Richmond (1974) and is termed as Corrected Ordinary Least Squares (COLS). The distributional assumptions obviously affect the results.

6 . See Greene (1980b) for a discussion.

7 . It is of course possible that more than one farm is technically efficient.

8 . The bounded range on the dependent variable problem does not occur with stochastic frontiers and hence a greater range of distributional assumptions may be used.

9 . Albeit an inconsistent estimate.

10 .Both available from Andre Croppenstedt.

11 . The greater flexibility of the Translog production function would add much to the analysis. However, for smaller data sets, one often (and we did) have a problem with multi collinearity (which may generate insignificant t-ratios and/or wrong signs on the coefficients). One solution to this problem, which is generally termed as a data problem is to increase the data size, whenever possible. Results by Huang and Bagi (1989) have shown that a more flexible functional form will generate lower (slightly) estimates of technical efficiency.

12 . The main advantage of COLS is low computational cost. However, with modern econometrics packages, such as GAUSS or LIMDEP, either problem is easy to compute.

13 . The exponential and the gamma distributions have also been used. As the latter is rather complex to implement, it has hardly ever been used. The fact that we have no good reason for choosing one distributional assumption over the other is a shortcoming of estimating technical efficiency using cross-sectional data.

14 . Teff (White and Black and Mixed Teff), Barely, Wheat, Maize, Millet and Sorghum.

15 . We are grateful to the Department of Economics at the Addis Ababa University for making the data available to us. The data were collected by the Department of Economics in collaboration with the Centre for the Study of African Economics at Oxford University. Funding was provided by SIDA.

16 . We in particular selected only those households who cultivate some land under cereals and deleted missing values and some extreme values for some of the variables.

17 . The weights being the relative proportions of the various cereals in the total value of output.composition.

18 . We used a variety of variables to obtain a good prediction of Labor, Oxen and Fertilizer. In particular, we used the number of ploughs owned, education of the head of the household, age of head of the household, average age of household members, five age groups for both male and female household members, the material of the walls and of the roof of the home, local rainfall, the price index, information on whether the head and the members could read or write, the time taken to collect fuel wood and water, and the exogenous variables in the equation.

19 . By regressing the square of the residual on the regressors, their squares and their cross-products (not including REG3 and REG9).

20 . We are grateful to Phillip Bevan who made her wealth codes available to us. This is a classification of farmers into 15 wealth related categories (and then into many sub-categories) by their peers. The data is large and for our purposes we only concentrated on a few sub-categories: drunkenness and chat addiction; farmers considered lazy or careless; very hard workers; innovative; good farmer; good manager. We note that for the last three categories, we had very few observations (between 0 and 5) and we used only the resulting proxies for the first three categories.

21 . We found a strong correlation between MAACT and the value of stored food (which we used as a proxy for wealth).

REFERENCES

Abrar Suleman. (1995) 'Evaluating the Efficiency of Farmers in Ethiopia', ***Ethiopian Journal of Economics***, II(2):47-66.

Agular, R. and A. Bigsten, (1994) 'An Analysis of Differences in Technical Efficiency Among Kenyan Smallholders', ***East Africa Economic Review***, 295-306.

Aigner, D., C. A. K. Lovell and P. Schmidt (1977) 'Formulation and Estimation of Stochastic Frontier Production Functions Models', ***Journal of Economics***, Vol. 6: 21-37.

Ali, F, A. Parikh and M. K. Shah (1994) 'Measurement of Profit Efficiency Using Behavioral and Stochastic Frontier Approaches', ***Applied Economics***, Vol. 26: 181-188.

Ali, M. And J. C. Flinn (1989) 'Profit Efficiency Among Basmati Rice Producers in Pakistan Punjab', ***American Journal of Agricultural Economics***, Vol. 71: 101-310.

Aly, H. Y. and R. Grabowski (1988) 'Technical Change, Technical Efficiency and Input Usage in Taiwanese Agricultural Growth', ***Applied Economics***, Vol. 20: 889-899.

Antle, J. M. and C. C. Crissman (1990) 'Risk, Efficiency and the Adoption of Modern Crop Varieties: Evidence from the Philippines', ***Economic Development and Cultural Change***, Vol. 38; 617-537.

Assefa Admassie. and F. Heidhues,)1996) 'Estimation of Technical Efficiency of Smallholder Farmers in the

Central Highlands of Ethiopia', *Ethiopian Journal of Agricultural Economics*, 1(1): 18-37.

Azhar, R. A. (1988) 'Education and Technical Efficiency in Pakistan's Agriculture', *The Pakistan Development Review*, Vol. 27: 687-695.

Azhar, R. A. (1991) 'Education and Technical Efficiency During the Green Revolution in Pakistan', *Economic Development and Cultural Change*, Vol. 39: 651-665.

Battese, G. E. (1990). Frontier Production Function, Technical Efficiency and Panel Data, unpublished paper, Department of Economietrics, University of New England, Armidale, Australia.

Battese, G. E. and T. J. Coelli (1992) 'Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India', *The journal of Productivity Analysis*, Vol. 3: 153-169.

Battese, G. E., T. J. Coelli and T. C. Colby (1989) 'Estimatiaon of Frontier Production Functions and the Efficiencies of Indian Farms Using Panel Data from ECRSISAT's Village Level Studies', *Journal of Quantitative Economics*, Vol. 5: 327-348.

Bauer, P. W. (1990b) 'Recent Development in the Econometric Estimation of Frontiers', *Journal of Econometrics*, Vol.46: 39-56.

Beckers, D. E. and C. J. Hammond (1987) 'A Tractable Likelihood Function for the Normal-Gamma Stochastic Frontier Model', *Economietrics Letters*, Vol. 24: 33-34.

Belbase, K ad R. Grabowski (1985) 'Technical Efficiency in Nepalese Agriculture', *Journal of Developing Areas*, Vol. 19: 515-525.

Croppenstedt, A. and Mulat Demeke, (1997) 'An Emprical Study of Cereal Crop Production and Technical Efficiency of Private Farmers in Ethiopia: A Mixed Fixed-random Cofficients Approach', *Applied Economics*, Vol. 29 (9): 1217-1226.

Coppenstedt, a. and Mulat Demeke, (1994). Measuring Technical Efficiency of Farmers in the Arssi Province of Shouthern Ethiopia: A Random Coefficients Approach, Mimeo, Department of Economics, Addis Ababa University.

Dawson, P.J. (1985) ' Measuring Technical Efficiency From Production Functions: some Further Estimaes', *Journal of Agricultural Economics*, Vol. 69: 31-40.

Dawson, P. J., J. Lingard and C. H. Woodford (1991). A Generalized Measure of Farm-specific Technical Efficieny, *American Journal of Agricultural Economics*, Vol. 73: 1098-1104.

Dejene A., A. Croppenstedt and and D. Mulat, (1994). On The Technical Efficiency of Peasant of Peasant Farmers in Ethiopia: Evidence from North Shewa and Arssi, Memeo, Department of Economics, Addis Ababa University.

Ekanayake, S. A. B. and S. K. Jayasuriya (1987) 'Measurement of Firm-specific Technical Efficiency: A Comparison of Methods', *Journal of Indonesian Economic Studies*, Vol. 25: 99-119.

Esparon, N. M. and N. H. Sturgess (1989) 'The Measurement of Technical Efficiency Using Frontier Production Functions of Rice Farms in West Java', *Bulletin of Indonesian Economic Studies*, Vol. 25: 99-119.

Fare, R., R. Gabowskin and S. Grosskopf (1985) 'Technical Efficiency of Philippine Agriculture', *Applied*

Economics, Vol. 17: 205-214.

Fare, R., S. Grosskopf and C. A. K. Lovell (1985). ***The Measurement of Efficiency of Production***. Boston: Kluwer-Nijhoff.

Farrell, M .J. (1957) 'The Measurement of Productive Efficiency', ***Journal of the Royal Statistical Society***, Vol. 120, Series A, part III: 253-281.

Flinn, J. C. and M. Ali (1986) 'Technical Efficiency in Basmati Rice Production', ***Pakistan Journal of Applied Economics***, Vol. 5: 63-79.

Forsund, F. R., C. A. K. Lovell and P. Schmidt (1980) 'A Survey of Frontier Production Functions and of their Relationship to Efficiency Measurement', ***Journal of Econometrics***, Vol. 13: 5-25.

Greene, W. H. (1980a) 'On the Estimation of a Flexible Frontier Production Model', ***Journal of Econometrics***, Vol. 13: 101-115.

Greene, W. H. (1980b) 'Maximum Likelihood Estimation of Econometric Frontier Functions', ***Journal of Econometrics***, Vol. 13: 27-56.

Greene, W. H. (1980c) 'Maximum Likelihood Estimation of Prametric Frontier Production Functions', ***Journal of Econometrics***, Vol. 13: 5-25.

Greene, W. H. (1982) 'Maximum Likelihood Estimation of Stochastic Frontier Production Models', ***Journal of Econometrics***, Vol. 18: 285-289.

Greene, W. H. (1990) 'A Gamma-distributed Stochastic Frontier Model', ***Journal of Econometrics***, Vol. 46: 141-163.

Hayam, Y. and V. W. Ruttan, (1989) ' The Green Revolution: Inducement and Distribution', ***The Pakistan Development Review***, Vol. 23 (1): 37-63.

Herdt, R. W. and A. M. Mandac (1981) 'Modern Technology and Economic Efficiency of Philippine Rice Farmers', ***Economic Development and cultural Change***, Vol. 29: 375-399.

Huang, C. J. and F. S. Bagi (1989) 'Technical Efficiency on Individual Farms in Northwest India', ***Southern Economic Journal***, Vol. 51: 108-115.

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

Kaliraja, K. (1981) 'The Economic Efficiency of Farmers Growing High-yielding, Irrigated Rice in India', ***American Journal of Agricultural Economics***, Vol. 63: 566-570.

Kalirajan, K. P. (1990) ' On Measuring Economic Efficiency', ***Journal of Applied Econometircs***, Vol. 5: 75-85.

Kalirajan, K P. and J. C. Flinn (1981) 'Comparative Technical Efficiency in Rice Production', ***Philippine Economic Journal***, Vol. 20: 31-43.

Kalirajan, K P. and J. C. Flinn (1983) 'The Measurement of Farm-specific Technical Efficieny', ***Pakistan Jouurnal of Applied Economics***, Vol. 2: 167-180.

Kalirajan, K P. and R. T. Shand (1985) 'Types of Education and Agricultural Productivity: A Quantitative Analysis of Tamil Nadu Rice Farming', ***Journal of Development Studies***, Vol. 21: 232-243.

Kalirajan, K. P. and R. T. Shand (1988) 'Estimating Location Specific and Firm Specific Technical Efficiency: An Analyiss of malaysian Agriculture', ***Journal of Economic Development***, Vol. 11: 147-160.

Kalirajan, K P. and R. T. Shand (1989) 'A Generalized Measure of Technical Efficieny', ***Applied Economics***, Vol. 21: 25-34.

Kumbhakar, S. C. (1987) 'The Specification of Technical and Allocative Inefficiency in Stochastic Production and Profit Frontiers', ***Journal of Econometrics***, Vol. 34: 335-348.

Lovell, L. A. K., (1993) 'Production Frontiers and Productive Efficiency', in H. O. Fried, C. A. K. Lovell and S. S. Schmidt (Eds.).***The Measurement of Productive Efficiency Techniques and Applications***. New York: Oxford Uiversity Press.

Meeusen, W. and J. Van Den Broeck (1977) 'Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error', ***International Economic Review***, Vol. 18: 435-444.

Moock, P. R. (1980-81) 'Education and Technical Efficiency in Small-farm Production', ***Economic Development and Cultural Change***, Vol. 29: 723-739.

Rawlins, G. (1985) 'Education and Technical Efficiency in Small-farm Production', ***Economic Development and Cultural Change***, Vol. 29: 723-739.

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

Richmond, J. (1974) 'Estimating the Efficieny of Production', ***International Economic Review***, Vol. 15: 515-521.

Schmidt, P. (1985-86) 'Frontier Prodcution Functions', ***Econometric Reviews***, Vol. 4: 289-328.

Schmidt, P. and C. A. K. Lovell (1979) 'Estimating Technical and Allocative Inefficiency Relative to Stochastic Production and Cost Frontiers', ***Journal of Econometrics***, Vol. 9: 343-366.

Shapiro, K. H. and J. Mueller (1977) 'Sources of Technical Efficiency: The Roles of Modernaization and Information', ***Economic Development and Cultural Change***, Vol. 25: 293-310.

Squires, D. and S. Tabor (1991) 'Technical Efficiency and Future Production Gains in Indonesian Agriculture', ***The Developing Economies***, Vol. 29: 258-270.

Stevenson, R. E. (1980) 'Likelihood Functions for Generalized Stochastic Frontier Estimation', ***Journal of Econometrics***, Vol. 13: 57-66.

Timmer, P., (1998) 'The Agricultural Transformation', in H. Chenery and T. N. Srinivasan (Eds..). **Handbook of Development Economics Vol. I.** North Holland: Elsevier Science Publishers, B.V.

Annex 1:-Description of variables that determine Technical Efficiency

BOA	Dummy if damage to crops due to birds and other animals, 1 if yes.
DU220	Dummy if a farmer is classified as lazy by peers, 1 if yes.
DU226	Dummy if a farmer is considered drunkard, or chat chewer by his peers, 1 if yes.
DU240	Dummy if a farmer is considered to be very hard worker by his peers, 1 if yes.
DUALP	Dummy if a farmer has the adult literacy certificate, 1 if yes.
DUFHH	Dummy for female headed households, 1 if yes.
DUOX	Dummy for farmer having at least two oxen, 1 if yes.
DURHA	Dummy if there was rain at harvest time, 1 if yes.
DUSCR	Dummy for sharecropping, 1 if yes.
EDHHH	Dummy for level of education of household head, 1 if the household head has completed primary school or more.
FRASHL A	Fraction of land cultivated which is sharecropped.
FW	Dummy if damage to crops due to flooding or water logging, 1 if yes.
ILL	Dummy if a farmer or household members too ill to work at an important time, 1 if yes.
LABH	Person days used for harvesting.
LATIM	Dummy if a farmer could not obtain labor at the right time, 1 if yes.
LOAN1	Dummy if a farmer got loan to buy farm or other implements, 1 if yes.
LOAN2	Dummy if a farmer got loan to buy inputs such as seeds, fertilizer or pesticides, 1 if yes.
LOAN3	Dummy if a farmer got loan to buy livestock, 1 if yes.
LOAN4	Dummy if a farmer got loan to pay for hired labor, 1 if yes.
MAACT	Dummy if a household sold some of crop in the market, 1 if yes.
OFY	Off-farm income.
OXTIM	Dummy if a farmer could not obtain oxen at the right time, 1 if yes.
PLOUGH	Number of Ploughs owned by the household.
RAIN	Dummy for rain at good time for the farmer, 1 if yes.
WDAM	Dummy if damage to crops is due to weed, 1 if yes.
WS	Dummy if damage due to wind and storm, 1 if yes.

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, PP. 63-100

THE EFFECT OF CHANGES IN DAIRY PRODUCTION TECHNOLOGY ON CONSUMPTION AND INTRA-HOUSEHOLD LABOUR ALLOCATION: A CASE STUDY OF FARM HOUSEHOLDS IN NORTH-WESTERN SHOA

Daniel Mebrate*

ABSTRACT: One of the agricultural policy goals in Ethiopia is to arrest the declining trend in dairy production. The response of the Ethiopian Government to these concerns has been the promotion of the crossbreeding of exotic cows with indigenous Zebu cows. A question for policy makers is whether such intervention is reversing the trend and benefiting the rural people. This study examines its effects on changes in dairy production technology, prices of outputs and labour on consumption and intra-household labour allocation. A farm household model is the analytical framework used to generate predictions about the responses of farm households based on comprehensive data collected from 60 households. The result of the analysis predicts a high scope for the government output price and technological intervention policy to affect consumption. However, labour allocation is not likely to be affected by prices, but is likely to be affected by a change in technology.

1. INTRODUCTION

In Sub-Saharan Africa (SSA) there is a concern about the rising degree of food insecurity and one area of emphasis is the degree of self-sufficiency in milk. This has also declined overtime, adding to the overall problem (Massow, 1989). Moreover, rapid increase in population, both in rural and urban areas, has raised demand for milk and consequent need for improved and sustainable milk production (Varvikko, 1992).

The central highland areas of Ethiopia have high potential for crop and livestock production compared with other agro-ecological zones (Gryseels, 1988). This indicates that cattle production, including dairying, could provide a means of increasing food production in these areas (Varvikko, 1992). The Ethiopian government, encouraged by the favourable agro-climatic environment in the highlands and positive experience with crossbred cows (CBCs) (Kiwuwa, 1983; Olsson, 1986), Schaar, 1981) has adopted a policy of crossing Freisian sires with indigenous Zebu cows Anon (1986). This technical change in production has, as its goal, a positive effect on production and consumption decisions of households.

* *Supervisor, Charter/Lease Market Development at Ethiopian Airlines. The article is based on MSc. thesis submitted to the Department of Economics, Addis Ababa University.*

Although technological interventions are expected to generate net benefits to farm households, they can have different implications for individual household members. There is some controversy regarding the economic gains of the rural poor from technological changes in agriculture. A review of studies by Binswanger and von Braun (1991) show that introduction of new technology resulted in higher farm production and profit to the adopters and expanded employment opportunities to the rural poor in most cases. However, they also reviewed studies where farm households failed to gain from technological change because of adverse institutional features (Binswanger and Braun, 1991).

von Braun (1988) and Puetz and Webb (1988) found irrigation technology and commercialization of rice to improve production and income of Gambians although it increased the demand for labour and work burden of the women (von Braun, 1988; 1989). Moreover, an impact assessment of new practices on the welfare of women in Burkina Faso found this new practices demanded more labour but the compensation the men paid the women (in the family) for latter's additional labour raised women's income level by about 224 percent Lawrence (1993). A similar finding was noted by (Lale, 1986).

Estimates of elasticities of consumption, labour demand and supply with respect to changes in farm technologies, wages and prices in multiple crop environment are limited. The following are estimates reported for some areas: own price elasticity of consumption of rice in Korea and sorghum in Nigeria are 0.01 and 0.19, respectively, assuming farm profits variable; and -0.08 and -0.05, respectively, assuming farm profits are constant (Singh, 1986). On-farm employment elasticities with respect to milk yield and price of labour are -0.62,-0.67, and -0.70 for Indian households rearing buffalo, indigenous cows, and crossbred cows, respectively (Lawani, 1990). Response elasticities of on-farm labour supply, own consumption of paddy, and consumption non-farm goods, to an increase in the price of paddy (wage rate) are 0.08 (-0.07), -0.04 (0.06) and -0.27 (0.29), respectively, assuming profits are constant, but -0.57 (0.12), 0.38 (-0.08) and 1.94 (-0.35) respectively, assuming farm profits are variable; and elasticities of own consumption of paddy, consumption of non-farm goods and labour supply to a change in farm technology, treating farm profits variable, are 0.42, 2.21 and -0.65 respectively while the elasticity of labour demand to an increase in price of paddy, wage rate and farm technology are 1.61, -0.47, and 1.61 respectively for households in Malaysia (Barnum, 1979).

In general these studies show that innovations such as crossbred cows require additional labour inputs, and that consumption of food and non-food items depends on income and prices of goods and services (Lawani, 1990). A rise in prices of commodities and incomes affect consumption of normal good negatively and positively, respectively. The net effect of simultaneous change in incomes and prices on consumption is that the profit effect is stronger and outweighs the price effect (Barnum, 1979; Singh, 1986).

In Ethiopia, an attempt to explore the effects of changes in technology, particularly in dairying, have focused on economic viability, acceptability of the technological package and productivity. However, few studies have assessed the effect of the introduction of the new breeds and complementary feed technologies on consumption and intra-household labour allocation. This study, therefore, focuses on (a) the effect of the introduction of CBCs on intra-household labour allocation, (b) the impact of CBC adoption on consumption of various commodities and (c) the policy implications of changes in variables exogenous to the households (technology, wages and prices) on household labour supply and employment expansion (the demand for hired labour).

2. THE THEORETICAL MODEL AND THE ISSUE OF ESTIMATION

The way in which farm households respond to technological interventions is the basis for determining the relative impact of alternative technologies. If, for example, an improved technology is introduced, will the income, and thus the consumption of the household rise? Will the demand for labour increase? And if so, will the increase in labour demand be met from household labour resources (men, women, or children), or will there be an increase in demand for hired labour? In order to answer these questions it is crucial to understand the microeconomic behaviour of farm households (Singh, 1986).

There are three possible ways in which household decision making might be viewed:

1. The household head as a dictator
2. The household head as an altruist
3. Co-operation/conflict between household members

The first possibility is that the household head acts as a dictator. He is the one who controls the labour supply of children and adult women and exploits their labour to his own personal advantage. Community pressure is said to maintain these traditional roles, to prevent rebellion by other family members, and to ensure that decisions are made by the household head in a dictatorial fashion.

A second view is that, the household head seeks to maximize the entire family's welfare or utility. The household decision making comes from the head, as in the exploitation case, but there could be consultation of adult members before making decision. This theory does not reveal the potential for conflicts and the different interests of household members.

The co-operation/conflict view suggests that household members decide simultaneously in areas of co-operation (pooling their available resources) and in areas of conflict (dividing total available benefits) Lawrence (1993).

Although the co-operation conflict pattern is the most consistently observed human and economic transaction of African households, it appears that altruism is the most apparent behaviour of households in the study area because in North-western Shoa Zone of Ethiopia there are no private plots for individual household members. All able household members work on family plots and share the benefits the household makes, the head being the major decision maker. Therefore, this study assumes altruistic behaviour of households to be most pertinent in the highlands of Ethiopia.

On the basis of altruistic behaviour of households, the model of Barnum and Squire (1979) was chosen to serve as a framework to generate predictions about the responses of farm households to changes in market variables (technology, prices, and wage rates). This model was particularly taken because its assumptions are relatively valid to the study area than other farm household models (Ellis, 1988). The rest of the section presents the basic model and discusses the issue of estimation.

2.1 The Basic Farm Household Model

The basic model has the following assumptions:

a) the household is considered as a single decision making unit,
b) households can hire in and out labour at the given market wage,
c) land available to the household and other capital inputs (livestock) are fixed for the production cycle,
d) home production activities (Z-goods) and leisure are combined with consumption items in order to maximize household utility,
e) the choice of the household is between own consumption of agricultural production and sale of agricultural production to purchase and consume non-farm consumption goods,
f) more than one variable input is assumed,
g) the household is a price taker for most inputs (if other than labour are accommodated), outputs and non farm consumption goods,
h) the household allocates its time to:

   i) home activities (including leisure),
   ii) off-farm and farm production,
   iii) wage employment.

2.2 The Model Structure

It is assumed that for any production cycle, the farm household maximizes a utility function:

$$U = U(C_d, C_a, C_m, C_v) \quad [1]$$

where the consumption commodities are dairy products (C_d), other agricultural goods (C_a), non-farm goods and services (C_m) and leisure (C_v). Utility is maximized subject to three constraints - cash income, time and production technology.
The income constraint is specified as:

$$P_m C_m = P_d(Q_d-C_d) + P_a(Q_a-C_a) - W(L_d-H_d) - W(L_a-H_a) + A \qquad [2]$$

The time constraint is specified as:

$$T = C_v + H_d + H_a \qquad [3],$$

and the technology constraint as:

$$Q_d = Q_d(L_d/F,X) \qquad [4]$$
$$Q_a = Q_a(L_a/F,X) \qquad [5]$$

Where

P_m, P_d and P_a	are price of non-farm goods and services, dairy products and other agricultural goods respectively.
Q_d and Q_a	are dairy products and other farm outputs respectively.
C_m, C_d and C_a	are consumption of non-farm goods and services, dairy products and other agricultural goods respectively.
(Q-C)	is marketed surplus.
W	is wage rate.
L_d and L_a	are total labour inputs allocated to dairy and other agricultural activities, respectively.
H_d and H_a	are household labour allocated to dairy and other agricultural activities respectively (so that L-H, if positive, indicates hired labour and, if negative, indicates household labour supplied out or household consumption of leisure).
A	is non wage, non agricultural, other net income.
F and X	are fixed land area and number of cows, respectively.
T	is total amount of household time available for allocation to work and leisure.

The above three constraints can be collapsed into one constraint. Substituting the production technology constraints into the cash income constraint for Q_a and Q_d, and substituting the time constraint into cash income constraint for H results in a single constraint of the form:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = P_dQ_d(L_d/F,X) + P_aQ_a(L_a/F,X) - W(L_a) - W(L_d) + WT + A$$

or:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = p + WT + A \qquad [6]$$

Where

$$\pi = P_dQ_d(L_d/F,X) + P_aQ_a(L_a/F,X) - WL_a - WL_d \qquad [7]$$

π is the measure of farm profit. The left side of equation 6 shows household expenditure on three groups of goods plus leisure and the right hand side constitutes Becker's concept of full income.

Equations 1, 4 and 7 are basic equations. Equations 1 and 7 show that households can choose consumption levels of the four types of commodities and the total labour demand in agricultural production, respectively.

$$\frac{\partial \Pi}{\partial L_a} = P_a \frac{dQ_a}{dL_a} - W \qquad [8]$$

By differentiating the profit function in equation 7 we get the first order conditions for profit maximization:

All the variables in equation 8 are exogenous except labour. Therefore, the other variables influence the household choice of labour. Equation 8 can be solved for L as a function of prices (P and W), the Dummy variable (D) (which takes a value of 1 if the household has CBC and 0 if the household has only LBC), output (Q), number of cows (X) and the fixed area of land (F). The solution for L can be expressed as:

$$L^*_d = L^*_d(P_d, W, D, X, F) \qquad [9]$$

$$L^*_a = L^*_a(P_a, W, D, X, F) \qquad [10]$$

Substituting the solution for L^* into equation 6, the value of full income is obtained. Therefore, equation 1.6 can be rewritten as:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = Y^* \qquad [11]$$

where Y^* (= p + WT + A) is the value of full income obtained when profit is maximized using L^*.

The demand functions for the four consumption commodity choices (C_m, C_d, C_a and C_v) in the utility function can be estimated by maximizing the utility function subject to the new version of the full income constraint (11).

The first order conditions are:

$$\frac{\partial U}{\partial C_m} = \lambda P_m$$

$$\frac{\partial U}{\partial C_d} = \lambda P_d$$

$$\frac{\partial U}{\partial C_a} = \lambda P_a$$

$$\frac{\partial U}{\partial C_v} = \lambda W \qquad [12]$$

and , $P_m C_m + P_d C_d + P_a C_a + WC_v = Y^*$ [11]

This is the standard condition from consumer demand theory. Solving equations 11 and 12 gives the demand curves of the form:

$$C_i = C_i(P_m, P_d, P_a, W, Y^*) \qquad [13]$$

Where $i = m, d, a$

Thus, the demand for commodity i depends on prices, wage and income. Household income is determined by household production decisions. Factors influencing production will change Y^* and the change in Y^* in turn affects consumption behaviour, under the assumptions that make the model recursive. Y^* is defined in terms of exogenous variables and is a function of the production function (Q) and labour allocated (L).

The full income equation is reformulated as:

$$Y^* = p(P, W ; a_i, X) + WL_1 t + A \qquad [14]$$

Where a_i is the technological parameter of the production function,
X is number of cows,
t is time available per able household member,
L_1 is able workers from the household members,

It follows that exogenous changes influencing output and labour usage will also affect Y^*. In order to investigate the role of family members in peasant economies, the unit of analysis has shifted from the household level down to that of household members and labour within the household is disaggregated by age and sex into child labour (l_c), adult male labour (l_m) and adult female labour (l_f). Thus, household labour supply L^* is the sum of men, women and children labour supplies ($L^* = \sum L^*_i$) and C_v is the sum of men, women and children leisure ($C_v = \sum C^i_v$) where " i " denotes men, women and children.

2.3 Estimation

In the empirical analysis, this study assumed recursiveness of the household model. For recursiveness to hold, three assumptions are necessary: first, there exists a market for all commodities (produced and consumed); second, such commodities are homogenous; and, third households are price takers (Singh, 1986: 89).

Normally if the error terms of input and commodity demand equations are uncorrelated, the entire system of equations would be statistically recursive. Thus, the input demand and commodity demand functions could be estimated separately. The practical advantage of separate estimation of both types of demand functions is that fewer parameters are needed. This would be important if the equations are non linear in the parameters. Single equation estimation of recursive models is also advantageous for it economizes on data requirements. To estimate a single equation, data is required for only one endogenous variable and for other exogenous variables, but not on all endogenous variables (Singh, 1986).

Therefore, this study assumed recursiveness of the model for the purpose of estimation (considering the sufficiency conditions of recursivness to be valid for the study area). A non-linear single equation was linearized and estimated for both commodities and labour demand functions. The estimation is carried out using the ordinary least square method.

3. TYPE AND SOURCE OF DATA AND METHOD OF DATA COLLECTION

3.1 Types of Data

This study employed cross sectional and time series farm-level data on production, consumption and labour allocation for 60 farm households in North-western Shoa. Two groups of households were considered. The first group were 30 households owning CBCs and the other 30 were LBC owners.

In order to estimate a complete set of commodity and input demand equations, data on household grain records, consumption expenditures, inputs, outputs, labour allocation, prices of farm and off-farm consumption commodities, wage for labour, and other sources of income were collected.

3.2 Sources of Data and Methods of Data Collection

The data on most of variables of interest for those who own CBCs were obtained from Livestock Policy Analysis Programme of the International Livestock Research Institute. The data for LBC owners were collected by the researcher. Structured questionnaires were employed to collect data for both groups of households. The selection of 30 CBC owners was carried out using stratified random sampling of 10 Peasant Associations (PAs) in three *Woredas* (Degem, Mukaturi and Debre-Tsege) of North-western Zone of Shoa.

The same questionnaire was used to collect data from LBC owners. The selection of 30 LBC owners was done by randomly choosing neighbouring households from the same PAs and *Woredas* from which the sample CBC owners were chosen.

All data are for calendar year 1993. However, there is a difference in the way the data were obtained for both groups of households. For CBC owners, the data were collected every week, for one year starting January 1993. For LBC owners, incomes and expenditures for 1993 were reconstructed from memory of farmer through interview using the structured questionnaires.

In order to minimize measurement or response error of the data from LBC households, besides the data collection which was based on what household heads recalled about 1993 income, consumption and labour allocation, etc., detailed data on LBC owners were collected for two months starting February 1994. This was carried out to know and verify the pattern of consumption and labour allocation of these households. These two variable groups were the most difficult ones for households to recall because they occurred more frequently during the year.

In computing full income for both groups of households, the estimates of home production was based on the harvest of 1993. Although consumption during 1993 was dependent on the crop harvest of 1992, this information was not available and it was assumed that the harvest of 1992 was similar to that of 1993. Moreover, in determining the reference year, the issues raised by Honthakker and Prais, quoted in Abebe (1989), were taken into consideration in computing income from production (Abebe, 1989; and Honthakker, 1971). Income of the household from crop production was, therefore, computed using the 1993 crop yield quantity.

Estimates of household expenditure are included both in consumption expenditure and production costs. Quantities of own production consumed were derived by subtracting sales, wages paid in kind, and crop shared out from production and by adding the net amounts obtained from the household grain record sheet (food aid, barter, gift and loan), wages earned and crop shared in-kind. Net changes in storage could not be determined because a considerable number of households were reluctant to disclose such information. Hence, net changes in storage were assumed to be zero. Quantities of own-production consumed were converted into values by multiplying them by average farmgate prices.

Items consumed by households were aggregated into eight groups of food, non food and household leisure. It was important to restrict the number of explanatory variables by aggregating consumption items, to avoid a degrees of freedom problem and to gain more precision in estimates (Strauss, 1993).

In aggregating commodities and computing group sales and purchase prices, only the most important items for the household were considered. The importance given to each consumption item was based on the budget share. Households were assumed to purchase goods of the same quality in different amounts because of differences in income and prices.

It was found from the survey results that farm households in the study area use only two markets and thus face basically uniform market prices for individual commodities. Thus, individual commodity prices were computed as the arithmetic means of the market prices collected over the year. Seasonality of prices was ignored since prices were not found to vary greatly over the study period. Average individual prices of similar commodities were then aggregated into average prices to form commodity groups.

Although the market prices in the study area do not vary, it is believed that the transaction costs incurred to obtain commodities does between households. These transaction costs would include differences in transport, time and information costs. Although commodities consumed by the sample farm households not vary greatly, the expenditure share of individual commodities does vary from household to household. Furthermore, the crop mixes of sample households was not found to vary greatly. The variation in commodity shares can thus be assumed to be due to differences in the transaction costs. To introduce this source of price variation into the data, average prices for commodity groups were weighted by the share of total household expenditure on each good in the consumption analysis. In the labour allocation analysis prices were weighted by the share of total household sales of each output group.

Price data is taken from the 1993 ILCA Market Survey. For goods and services not considered in ILCA's Market Survey, 1986-1990 data obtained from a series of statistical bulletins of CSA were employed to estimate 1993 prices. First, the average retail prices of goods and services in Rural Northern Shoa were obtained for the period 1986-1990 and the average rate of change for each good and service was computed using these data. Then, the 1993 prices were estimated using the computed average rate of change.

Household labour supply data for CBC owners for dairying, crop production and marketing were obtained from the ILCA survey. The labour allocation data for LBC owners were computed from CBC owners labour allocation data. The computation of annual labour supply of these households for dairying and marketing of farm products for the year 1993 were carried out on the basis of the two months data (February and March 1994) collected. Labour supply data for crop production were estimated following the labour allocation pattern of the other 30 CBC owner households for which annual labour data were available.

This study made the strong assumption that all farms employ the same technology, producing the same type of crops and cultivating the same area of land and supply the same amount of labour. The supply of family labour could vary across households due to variation in household characteristics (total size and age composition of households), area cultivated and the type of crops they grow. Since the labour data for LBC households was not available, their labour supply for a certain crop land per hectare was approximated by the average labour required per hectare for CBC owner farms which produced that crop. Wages were expressed in Birr/day.

Household demographic and related data such as household major (full-time) and minor (part-time) occupations, age composition, sex, educational level, relation of each household member to the household, marital status of household members is collected by the author. In order to know the family size and total available labour in the household, this information was converted into man-equivalents to obtain total standardized household labour units.

Land was measured as total cropped area in 1993, in hectares. It was only annual crop fields that were measured. Information on the differences in the quality of cropped land was not available.

4. RESULTS OF THE STUDY

4.1 Consumption Responses of Agricultural Households

Agricultural household models assume that agricultural households will determine the level of consumption of groups of commodities that will provide members with maximum utility given the amount of household income available (including dairy profits), time and the technology in use. One key hypothesis tested in this study is that the farm households make rational consumption decisions in response to changes in dairy technology and such decisions are a function of profits from dairying, prices of consumption items, and the prevailing agricultural wage.

This study grouped consumption items into eight categories: 1) major staple crops (barley, *teff* and wheat); 2) other crops; 3) non-dairy livestock and livestock products; 4) non-farm goods and services; 5) milk; 6) butter; 7) cheese; and 8) leisure. This disaggregation of commodities was made to assess the consumption response of households to broad categories of commodities.

Consumption is hypothesized to be a functions of the following variables:

$$C_i = C_i (P_{a1}, P_{a2}, P_l, P_m, P_k, P_b, P_c, W, Y^*) \qquad [15]$$

Where: C_i = consumption of commodity i (measured in Birr),
i = a1, a2, l, m, k, b, c, and v
a1 = major staple crops (barley, *teff* and wheat),
a2 = other crops,
l = non-dairy livestock and livestock products,
m = non-farm goods and services,
k = milk, b = butter, c = cheese,
v = leisure, P_i = price of consumption items,
W = price of leisure,
Y^* = profit from dairying.

The price of leisure (2.75 Birr/day) is the average wage rate households face in the rural labour market.[1] This is the opportunity cost of leisure. The rate is assumed to vary across households by the share of leisure consumption in total consumption. It is computed as:

$$W = \frac{2.75}{(C_v \times 2.75)/\left(\sum C_i \times P_i\right)}$$

Like the price for leisure, households also face the same unit average price for the other seven groups of consumption items. These items are also assumed to vary across households according to transaction costs that are embedded in the consumption shares. The same weighing algorithm is employed for commodity prices.

$$P_i = \frac{P_i}{(C_i \times P_i)/\left(\sum C_i \times P_i\right)}$$

Where P_i is average purchase price of good *i*

The level of consumption of each group of commodity, including leisure, depends on prices of commodities consumed, the opportunity cost of leisure (termed 'wage') and dairy profit. The profit from dairy is in turn dependens on the rural wage, prices of consumption items, and the technology used in dairying.

Households allocate their time for farm work, wage employment and leisure. For the purpose of utility maximization in the model, households time devoted to the production of non-farm goods (home produced or Z-goods) and leisure are combined into one consumption item termed simply as *leisure*. Leisure is considered to be a normal good. The income effect of leisure is assumed to be positive and that of Z-goods negative. The income effect of leisure is also assumed to outweigh the negative income effect of Z-goods.

Total household leisure is derived in this study as a residual by subtracting total time the household allocates to crop and livestock production (including marketing) from total time available. The formula employed to derive total household leisure time is:

$$C_v = \begin{pmatrix}\text{Total number of}\\ \text{days available}\end{pmatrix} - \begin{pmatrix}\dfrac{\text{Total hours worked for crop production}}{1.50 \text{ hours}}\end{pmatrix} - \begin{pmatrix}\dfrac{\text{Total hours worked for livestock production}}{4.20 \text{ hours}}\end{pmatrix}$$

Where: C_V = *Household leisure days.*

The length of work hours/day for different activities and each type of household member is different[2] The average annual number of working days available for crop production and livestock production, in the study area, are 185 and 365 days, respectively.

The hypotheses regarding the factors affecting consumption or demand for consumption items is shown by comparing own and cross price elasticities of demand in two separate regressions: first, when the response of consumption of groups of commodities are estimated under the assumption that dairy profits are constant; and second, when the response of consumption to changes in prices and wages incorporate changes in dairy profits.

The compensated elasticities with respect to prices are thus computed on the assumption that dairy profits are variable. Dairy profits are part of total profits earned by the households. In order to assess the effect of the technology on consumption, it is only the profit from dairying that is considered to vary in the analysis. Profit earned from crop production is considered to be constant across CBC and LBC households. A regression of diary profit on prices and crop production profit has shown that the variation in dairy profit is not explained by variation in crop production profit. There is no contribution of the profit from crop production (the other main source of income) to dairy profit or dairy income[3] . Therefore, dairy profit can stand on its own to assess the impact of the technology on the consumption of the various groups of commodities.

The estimated regression coefficients are found to have theoretically expected signs and statistically significant for about 28 percent of the coefficients estimated (Table 4.1). In most of the cases the calculated value of the F-ratio is found to be larger than its tabulated value at the 1 percent level, indicating the overall significance of the regression equation. However, in most cases, low values for the adjusted coefficient of multiple determination (R^2) were observed, indicating that much of the variation in consumption is not explained by the regressors used.

The own price consumption elasticities are negative for all commodity subgroups except that of butter (not significant statistically, however), assuming dairy profits constant (Table 4.1). Demand theory suggests that own consumption of normal goods decrease when their prices increase. The results of the computed elasticities for all items, except for butter, are consistent with the theory when farm households are treated only as consumers. In the case of butter the own price elasticity is positive. This implies that butter is an inferior good to these households. However, in the case of butter, since all that which is consumed in the house is produced in the house, an increase in the price of butter through a positive income effect, may result in less butter to be sold and more to be consumed by the household.

The sign of the computed cross price elasticities (Table 4.1) show that cheese is the only complement item to major staples while butter and cheese are complements to other crops.

Non-dairy items and milk are substitutes for crops. The three dairy products (milk, butter and cheese) are complementary with each other but are substitutes for other items. Of all the cross price elasticities computed, the cross price elasticity values of non-farm goods and services are the highest. These elasticity values predict that, compared to a change in prices of other items, the price of manufactured goods would increase the consumption of commodities.

In traditional demand theory, an increase in the wage rate implies an increase in farm income and, therefore, consumption of non-leisure goods but a decrease in leisure (an increase in labour supply). Except one negative coefficient value, the computed elasticities are mostly positive although all are not significant at 10 percent level.

The integrated household model that includes both production and consumption shows somewhat different results. An increase in wage in this case is an increase in costs to the household. Therefore, households profit would decrease and thereby consumption. A change in sign to negative coefficients is observed in some cases, while there is a decrease in the magnitude of positive wage coefficients and they become close to zero in other cases.

The own price effects are not offset by the income effect in the integrated household models (Table 4.2). Own consumption effects of prices do not change sign when dairy profits are added to the models. This implies that the price (substitution) effect is stronger than the profit effect. However, in most cases the net effect of profit and substitution effects are lower in the integrated models than the traditional models (where only price effects are taken into consideration). Nevertheless, in two cases, for major staples and non farm goods and services, higher negative own-price effects are observed after profit effects are added. The computed own price elasticities for major staples and non-farm goods and services are -0.94 and -0.28, respectively. These results indicate that an increase in dairy profits tend to improve household consumption of these important items.

The strength of dairy profit effect to outweigh the substitution (price) effect is thus low at the existing level of dairying of these households. However, the coefficients for dairy profits are higher for milk and butter than any other consumption items in the regression equations. CBC owners, as can be seen in Table IV of the Appendix 1, consumed more of each group of these items than LBC owners. Higher dairy profits of CBC owners than LBC owners can be considered to improve dairy products consumption of CBC households.

Table 4.1 Uncompensated Elasticities of Consumption of Various Groups of Items, Assuming Dairy Profits Constant

With respect to	Elasticity of consumption of							
	Major staple crops	Other crops	Non-dairy livestock and livestock products	Non-farm goods and services	Milk	Butter	Cheese	Leisure
price of major staple crops	-0.88 (-3.47)***	0.11 (0.39)	2.3 (2.97)***	0.38 (1.53)	0.84 (0.91)	1.7 (1.92)*	0.47 (0.6)	0.32 (0.34)
price of other crops	0.21 (1.2)	-1.02 (-4.94)***	1.36 (2.46)**	0.19 (1.05)	0.42 (0.63)	1.46 (2.31)**	-0.2 (-0.36)	-0.12 (-0.18)
price of non-dairy livestock and livestock products	0.43 (2.79)***	0.05 (0.28)	-1.03 (-2.19)**	0.21 (1.42)	0.58 (1.03)	1.21 (2.25)**	1.02 (2.15)**	0.60 (1.03)
price of non-farm goods and services	1.18 (5.17)***	0.91 (3.51)***	1.03 (1.49)	-0.11 (-0.5)	1.39 (1.69)*	2.78 (3.50)***	0.83 (1.2)	1.40 (1.62)
price of milk	0.22 (1.88)*	0.1 (0.72)	0.43 (1.2)	0.04 (0.32)	-1.17 (-2.8)***	-0.07 (0.16)	-0.31 (-0.87)	-0.38 (-0.86)
price of butter	0.11 (0.58)	-0.15 (-0.68)	0.74 (1.26)	0.03 (0.17)	-0.01 (-0.02)	0.02 (0.03)	-0.56 (-0.96)	0.48 (0.67)
price of cheese	-0.08 (-0.86)	-0.01 (-0.14)	0.43 (1.57)	0.09 (0.99)	-0.3 (-0.93)	-0.61 (-1.96)*	-1.15 (-4.18)***	-0.33 (-0.99)
wage	0.05 (0.67)	-0.07 (-0.77)	0.18 (0.75)	0.01 (-0.18)	0.12 (0.42)	0.26 (0.93)	0	-0.01 (-0.02)
F	16.08***	9.16***	2.59**	1.06	2.37**	4.02***	6.57***	0.93
R^2	0.67	0.53	0.18	0	0.15	0.29	0.43	0

T - values are shown in parenthesis.

***, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.

Table 4.2 Compensated Elasticities of Consumption of Various Groups of Items, With Dairy Profits Assumed Variable

With respect to	Elasticity of Consumption							
	Major staple crops	Other crops	Non-dairy livestock and livestock products	Non farm goods and services	Milk	Butter	Cheese	Leisure
Price of major staple crops	-0.94 (-3.81)***	0.05 (0.16)	2.31 (2.94)***	0.32 (1.35)	0.38 (0.58)	1.24 (2.07)**	0.1 (0.18)	-0.01 (-0.02)
Price of other crops	0.22 (1.24)	-1.02 (-5.21)***	1.36 (2.44)**	0.18 (1.10)	0.40 (0.86)	1.44 (3.4)***	-0.21 (-0.52)	-0.14 (-0.23)
Price of non-dairy livestock and livestock products	0.28 (1.74)*	-0.14 (-0.76)	-1.0 (-1.92)*	0.05 (0.30)	-0.67 (-1.55)	-0.06 (-0.15)	0	-0.32 (-0.58)
Price of non-farm goods and services	1.03 (4.51)***	0.72 (2.82)***	1.07 (1.46)	-0.28 (-1.25)	0.16 (0.27)	1.53 (2.75)***	-0.16 (-0.31)	0.48 (0.62)
Price of milk	0.26 (2.26)**	0.14 (1.13)	0.42 (1.16)	0.08 (0.72)	-0.86 (-2.85)***	0.25 (0.92)	-0.05 (-0.2)	-0.14 (-0.37)
Price of butter	0.16 (0.85)	-0.09 (-0.42)	0.72 (1.22)	0.09 (0.48)	0.39 (0.78)	0.43 (0.94)	-0.24 (-0.55)	0.77 (1.22)
Price of cheese	-0.05 (-0.55)	0.02 (0.23)	0.42 (1.51)	0.12 (1.43)	-0.06 (-0.24)	-0.36 (-1.7)*	-0.95 (-4.62)***	-0.15 (-0.52)
Wage	0.05 (0.62)	-0.08 (-0.91)	0.18 (0.74)	-0.02 (-0.28)	0.07 (0.32)	0.21 (1.10)	-0.04 (-0.23)	-0.05 (-0.17)
Y^*	0.07 (2.25)**	0.09 (2.56)**	-0.12 (-0.16)	0.08 (2.64)***	0.62 (7.11)***	0.63 (7.93)***	0.5 (6.55)***	0.46 (4.1)***
F	15.99***	9.76***	2.26**	1.83*	9.77***	14.89***	15.39***	3.0***
^{2}	0.70	0.57	0.16	0.11	0.57	0.68	0.69	0.23

T - values are shown in parenthesis. ***, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.

4.2 Household Labour Allocation Response

Farm household members allocate their time for farm work, wage employment, off-farm work and leisure. Changes in prices, wage and dairy profits (through a change in technology) cause household members to restructure labour allocation (family labour supply and demand for different farm activities).

4.2.1 Household Labour Demand

Household labour demand for crop and livestock production is the total quantity of labour the household demands for these farming activities. This study attempted to assess the demand for labour by incorporating only prices of outputs and the marginal physical product of labour (assumed to be captured by a dummy variable, 1 = if the household owns CBC, 0 = other wise) into the labour demand functions. The demand functions for crop, livestock and total production, thus, have the form:

$$L^* = L^* (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \quad [16]$$

$$L^*_a = L^*_a (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \quad [17]$$

$$L^*_d = L^*_d (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \quad [18]$$

Where L^* *total household labour demand for crop and livestock production,*
L^*_a *household labour demand for crop production,*
L^*_d *household labour demand for livestock production,*
P_j *sales price of good j, where j = a1, a2, l, k or b,*
a_1 *major staple crops (barley, teff and wheat),*
a_2 *other crops,*
l *non-dairy livestock and livestock products,*
k *milk,* b - butter, W - wage
D dummy variable (1 = if the household owns CBC, 0 = otherwise),
F/L Land/labour ratio.

As is the case for the purchase prices of consumption items, households face the same sales prices of outputs P_j and wage rate (W). Again, in order for wage and prices to vary across households, the following weighing method is employed.

$$P_j = \frac{\text{Average sales price for good j}}{(q_j \times p_j)/\left(\sum q_j \times p_j\right)}$$

Where j = *a1, a2, l, k, and b.*
qj = *quantity of item j sold.*

Wage rate is weighed using the same procedure.

For the purpose of assessing labour demand response, the specified demand functions were transformed into linear logarithmic forms and were then estimated. The estimated labour demand functions for crop, livestock and both crop and livestock productions are shown in Table 4.3.

The coefficients for wage are negative in conformity with economic theory and are also inelastic (but only significant in the case of total labour demand). The estimated coefficients imply that a 10 % increase in wage would decrease labour demand for crop, livestock and total farming by 1.4 %, 1.1 % and 1.2 %, respectively. Thus, a change in wage rate does not affect labour demand much. This is because hired labour participation is very low in farming and labour exchange arrangements are a more typical means of overcoming labour shortages (basically with little cost). Table 4.8 shows hired labour participation in relation to hired labour cost.

The estimated value of the intercept shifter variable, the dummy, shows that a shift from LBC to CBC dairying increases the labour demand for crop and livestock production significantly. This is plausible since CBC owners have larger size plots than LBC owners and dairying with CBC requires labour for additional feed production, other dairy activities and marketing of the outputs. The coefficient for the dummy variable in case IA (crop production) is elastic while in case IB (livestock production) is inelastic. The value of 1.29 for the intercept shifter variable (the dummy) in case IA implies that as a result of CBC introduction the intercept of the crop labour demand curve shifts upwards with the same slope of the curve. The same explanation holds for the coefficients 0.44 and 0.57 in cases IB and IC, respectively.

Table 4.3 Elasticities of Farm Labour Demand for Crop, Livestock and Both Crop and Livestock Productions.

With respect to	Elasticity of Farm Labour Demand for		
	Crop production (IA)	Livestock production (IB)	Both crop and livestock production (IC)
price of major staples (Barley, *teff* and wheat)	-0.06 (-0.83)	-0.07 (-1.5)	-0.07 (-1.57)
price of other crops	-0.01 (-0.09)	0.02 (0.27)	0.02 (0.28)
price of non-dairy livestock and livestock products	0.15 (1.09)	-0.05 (-0.53)	-0.02 (-0.19)
price of milk	-0.05 (-1.09)	0.02 (0.5)	0
price of butter	0.08 (0.98)	-0.05 (-0.82)	-0.01 (-0.24)
wage	-0.14 (-1.25)	-0.11 (-1.4)	-0.12 (-1.67)*
dummy variable	1.29 (8.07)***	0.44 (3.94)***	0.57 (5.29)***
land labour ratio	0.17 (1.25)	-0.15 (-1.58)	-0.12 (-1.34)
F	14.90***	2.55**	4.78***
R^2	0.65	0.17	0.33

t - values are shown in parenthesis

***, **, * denote significant coefficients at 1 percent, 5 percent and 10 percent levels respectively.

The estimated output price elasticities of labour demand are inelastic and not significant. An increase in price of a particular output does not increase labour demand. Theoretically, labour demand is responsive to price especially when the activity corresponding to the price change is important. Nonetheless, the coefficients for the output prices show that labour demand is not price responsive and only a few coefficients were found to have signs that confirm the theory. This does not, however, mean that all the activities considered are not important to the household but that labour demand is influenced more by the type of technology than the prices of outputs and wage.

4.2.2 Household Labour Supply

Technology also affects family labour supply. Labour supply response to changes in technology is considered to be more relevant from a policy standpoint than the demand for leisure. The labour supply functions used for the analysis are derived from leisure demand functions directly by means of the formula:

$$\frac{\partial S}{\partial Y^*} = - \frac{\partial C_v}{\partial Y^*}$$

To express this as an elasticity

$$\frac{\partial S}{\partial Y^*}\frac{Y^*}{S} = - \frac{\partial C_v}{\partial Y^*}\frac{Y^*}{S}$$

$$= - \frac{\partial C_v}{\partial Y^*}\frac{Y^*}{S}\frac{C_v}{S} \qquad [19]$$

Where S *stands for household labour supply,*
C_V *stands for household demand for leisure,*
Y^* *stands for household profit from dairying.*

The total family labour supply for both crop and livestock production is the summation of labour supplies of men, women and children. Theoretically, the labour supply of the household and its members (men, women, and children) for a particular activity is a function of household income, wage rate of labour in farming, wages that can be earned from other occupations, and the condition of the job (non pecuniary aspects of the job)[4]. Changes in factors other than the wage rate of labour in farming can shift the supply of labour curve.

Two of the factors that shift the labour supply curves, wages that can be earned from other occupations and the condition of the jobs, are less likely to affect households labour supply in the study area. This is because in the rural areas there are no other activities than farming that require hired labour. The conditions of the jobs available are not important either due to limited opportunities. Therefore, these two factors are not included as variables in the specified labour supply functions. The specified labour functions, thus, have the form:

$$S_{ij} = S_{ij}(\ P_a1\ ,\ P_a2\ ,\ P_l\ ,\ P_k\ ,\ P_b\ ,\ W\ ,\ Y^*\ ,\ \frac{F}{L} \qquad [20]$$

where i = labour supply of men, women, children or the household as a unit,

j = crop, livestock, or both crop and livestock production activities.
P_{a1} = price of major staple crops (Barley, *teff* and wheat),
P_{a2} = price of other crops,
P_l = price of non-dairy livestock and livestock products,
P_k = price of milk,
P_b = price of butter,
W = agricultural wage rate,
y^* = profit from dairying,
F/L = Land/labour ratio.

The labour supplied of men, women and children (S_j) to crop and livestock production are obtained by dividing the hours allocated to crop and livestock production (all converted into man equivalent hours) by the number of economically active members of the household (number of standardized household labour units between age 8 and 75)[5].

The values for the price of crops, livestock products, and labour (wage) for each household is based on the same procedure used in computing prices and wage values in the labour demand functions. The labour supply functions are also transformed to linear logarithmic form for estimation. The estimated labour supply functions for crop, livestock and the combined crop and livestock production is given in Table 4.4.

The computed values of F are significant at the 10 percent level, showing the joint significance of the explanatory variables. However, in these three cases the observed adjusted coefficients of multiple determination (R^2) are low. The estimated regression coefficients are all inelastic, have statistical significance for some of the variables and expected signs for most coefficients in the integrated models. Nevertheless, the estimated labour supply function for livestock production, assuming dairy profits constant, shows that the regression equation is not significant.

For comparison, two regressions of the same labour supply functions are run, assuming dairy profits constant in one case and variable in another. In all the three cases, the estimated elasticities of the integrated model are different from the traditional ones (which do not incorporate dairy profits into the model).

Table 4.4 Elasticities of Household Labour Supply to Crop, Livestock and Both Crop and Livestock Productions

With respect to	Elasticity of Household Labour Supply to					
	Crop (IIA)		Livestock (IIB)		Both (IIC)	
	a	b	a	b	a	b
price of major staples	0.02 (0.24)	-0.05 (-0.68)	-0.15 (-1.8)*	-0.05 (-0.54)	-0.11 (-1.86)*	-0.04 (-0.68)
price of other crops	0.05 (0.55)	-0.01 (-0.06)	-0.03 (-0.32)	0.05 (0.5)	-0.01 (-0.12)	0.05 (0.64)
price of non-dairy livestock and livestock products	0.19 (1.31)	0.03 (0.16)	-0.28 (-1.7)*	-0.03 (-0.19)	-0.19 (-1.53)	-0.02 (-0.14)
price of milk	-0.08 (-1.72)*	-0.04 (-0.82)	0.08 (1.47)	0.02 (0.34)	0.05 (1.29)	0.01 (0.24)
price of butter	0.01 (0.09)	0.03 (0.35)	-0.1 (-1.02)	-0.13 (-1.44)	-0.08 (-1.05)	-0.1 (-1.43)
wage	0.05 (0.44)	0.06 (0.56)	-0.04 (-0.32)	-0.06 (-0.48)	-0.04 (-0.38)	-0.05 (-0.53)
dairy profits (y^*)	-	0.09 (2.17)**	-	-0.13 (-2.94)***	-	-0.09 (-2.7)
land labour ratio	0.59 (3.97)***	0.59 (4.12)***	0.15 (0.89)	0.15 (0.94)	0.23 (1.84)*	0.23 (1.95)*
F	4.08***	4.41***	1.72	2.8**	2.06*	2.94***
R^2	0.27	0.32	0.08	0.20	0.11	0.21

t - values are shown in parenthesis
a)- dairy profits assumed constant
b) - dairy profits assumed variable
****, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

In the case of household labour supply to crop production, the regression coefficients are significant at 1 percent level under the assumptions of both constant and variable diary profits. Of the nine elasticities reported for comparison (under a and b of Table 4.4) two of them have different signs while the other four differ in magnitude but with the same sign. It is the joint effects of prices, wage and income (dairy profit) that account for these differences.

Traditional labour supply theory suggests that an increase in the price of an output that uses labour in production would increase household supply of labour. The estimated elasticities with respect to prices of major staples and other crops are 0.02 and 0.05, respectively. This result consistent with the theory. An increase in wage should also increase household supply of labour by decreasing hiring in of labour. The estimated elasticity is 0.05, which although not significant, is consistent with the theory.

The integrated models predict a decrease in family labour supply due to an increase in price, labour supply and wage. The estimated elasticities of family labour supply to crop production with respect to prices of major staples and other crops are -0.05 and -0.01 respectively, although these coefficients are not significant at 10 percent level.

In the traditional model, a unit increase in the prices of milk and butter change the family labour supply to crop production by -0.18 and 0.01 respectively (the response of household labour supply to butter price is not significantly different from zero, however). The profit effect in the integrated model could not offset the effect of milk price, but the magnitude is reduced (although it still maintains a negative sign). This result suggests that in the short run an increase in price of non-crops is less strong in affecting family labour supply to crop production than an increase in crop prices.

Table 4.5 Elasticities of Total Labour Supply of Men, Women and Children

With Respect to	Elasticity of Total Labour Supply of					
	Men (IIIA)		Women (IIIB)		Children (IIIC)	
	a	b	a	b	a	b
price of major staples	-0.14 (-1.46)	-0.19 (-1.75)*	0.02 (0.24)	0	-0.12 (-0.64)	0.15 (0.8)
price of other crops	(0.06) (0.49)	0.02 (0.19)	0.1 (0.93)	0.08 (0.75)	-0.08 (-0.32)	0.15 (0.64)
price of non-dairy livestock and livestock products	0.05 (0.26)	-0.06 (-0.25)	0.27 (1.64)	0.23 (1.2)	-0.61 (-1.6)	0.05 (0.12)
price of milk	0	0.02 (0.34)	-0.08 (-1.39)	-0.06 (-1.09)	0.1 (0.77)	-0.07 (-0.54)
price of butter	0.02 (0.21)	0.04 (0.33)	-0.15 (-1.47)	-0.14 (-1.39)	-0.32 (-1.39)	-0.4 (-1.94)*
wage	-0.16 (-0.95)	-0.15 (-0.9)	0.17 (1.25)	0.18 (1.27)	0.33 (1.04)	0.28 (0.97)
dairy profits (y^*)	–	0.06 (1.02)	–	0.02 (0.49)	–	-0.35 (-3.5)***
land labour ratio	0.21 (1.05)	0.21 (1.05)	0.02 (0.11)	0.02 (0.11)	-0.11 (-0.28)	-0.11 (-0.32)
F	0.95	0.96	1.78	1.56	1.02	2.62**
R^2	0.00	0.00	0.08	0.07	0.00	0.18

t - values are shown in parenthesis

a) dairy profits assumed constant

b) dairy profits assumed variable

****, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

The effect of technology is captured again here by the dummy variable dairy profit[6]. The integrated model shows that household labour supply to crop production (IIA in Table 4.4) increases with an increase in dairy profits. Family labour supply to livestock production (IIB) and in general to farming (IIC), however, decreases with an increase in dairy profits. These are indicated by elasticities 0.09,-0.13 and -0.09 in IIA, IIB, and IIC, respectively. All are significant at the 5 percent level.

These three elasticities indicate that a 1% increase in dairy profit decrease total family's labour supply to livestock production by 0.13% and increase total family's labour supply to crop production by 0.09%. The net household labour supply response is, however, a decrease in labour supply (the elasticity is -0.09). This means a 10 percent increase in dairy profit would decrease total family labour supply by 0.9 percent. The household labour supply response does not reveal the change in labour force participation of men, women and children to crop and livestock production. Men, women and children labour supply responses with respect to prices, wage, and dairy profits are shown in Table 4.5.

The estimated coefficients in cases IIIA and IIIB, as indicated by the F-ratios, are not significant at the 10 percent level and the regression lacks information (as R^2 shows value around 0). For children labour supply (case IIIC), however, the calculated value of F-ratio was found to be higher than its tabulated value at the 10 percent level. The estimated regression coefficients in the integrated models show that children decrease their supply of labour with an increase in household profits from dairying.

The above general predictions for total labour supply responses to a change in dairy profit is the net effect of each member's supply responses to livestock and crop productions. The regression equations for men (VA), women (VB) and children (VC) labour supply to livestock production is shown in Table 4.6.

Table 4.6. Elasticities of Labour Supply for Men, Women and Children to Livestock Production

With Respect to	Elasticity of Labour Supply of					
	Men (VA)		Women (VB)		Children (VC)	
	a	b	a	b	a	b
price of major staples	-0.52 (-2.23)**	-0.46 (-1.8)*	0.06 (0.65)	0.03 (0.35)	-0.12 (-0.62)	0.16 (0.82)
price of other crops	0.02 (0.08)	0.07 (0.23)	0.08 (0.67)	0.06 (0.47)	-0.11 (-0.44)	0.12 (0.52)
price of non-dairy livestock and livestock products	0.16 (0.34)	0.3 (0.55)	0.31 (1.7)*	0.25 (1.21)	-0.66 (-1.66)	0.02 (0.05)
price of milk	-0.06 (-0.42)	-0.1 (-0.59)	-0.09 (-1.5)	-0.07 (-1.16)	0.1 (0.8)	-0.06 (-0.51)
price of butter	0.16 (0.59)	0.15 (0.52)	-0.15 (-1.36)	-0.14 (-1.27)	-0.33 (-1.41)	-0.42 (-1.96)*
wage	-0.16 (-0.42)	-0.17 (-0.44)	0.18 (1.19)	0.19 (1.21)	0.3 (0.92)	0.25 (0.84)
dairy profits (y^*)	-	-0.07 (-0.54)	-	0.03 (0.58)	-	-0.36 (-3.49)***
land labour ratio	-0.28 (-0.58)	-0.28 (-0.58)	-0.02 (-0.1)	-0.12 (-0.1)	-0.15 (-0.37)	-0.15 (-0.41)
F	1.01	0.91	1.75	1.55	1.09	2.67***
R^2	0.00	0.00	0.08	0.07	0.01	0.19

t - values are shown in parenthesis,

a) dairy profits assumed constant,

b) dairy profits assumed variable,

***, **, * *denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

The estimated regression coefficient when dairy profit is included is found to be inelastic and statistically significant for the case VC (children labour supply to livestock production). The regression for men and women livestock labour supply is not significant at the 10 percent level. The estimated elasticity when dairy profit is included in case of VC is -0.36. This elasticity suggests that a 10% increase in dairy profit decreases the labour supply of children by 0.36%. This result implies that it is mainly children's labour supply to livestock production that is reduced as the household shifts from LBC to CBC dairying.

Table 4.7 Elasticities of Labour Supply for Men, Women and Children to Crop Production

With Respect to	Elasticity of Labour of					
	Men (IVA)		Women (IVB)		Children (IVC)	
	a	b	a	b	a	b
price of major staples	0.05 (0.43)	-0.11 (-0.96)	-0.43 (-2.15)**	-0.45 (-2.03)**	0.06 (0.28)	-0.04 (-0.19)
price of other crops	-0.04 (-0.25)	-0.17 (-1.19)	0.42 (1.6)	0.4 (1.47)	0.22 (0.84)	0.14 (0.5)
price of non-dairy livestock and livestock products	0.3 (1.24)	-0.09 (-0.35)	-0.3 (-0.74)	-0.35 (-0.75)	0.1 (0.24)	-0.14 (-0.29)
price of milk	-0.09 (-1.12)	0.01 (0.13)	-0.14 (-1.09)	-0.13 (-0.92)	-0.14 (-1.02)	-0.08 (-0.53)
price of butter	-0.05 (-0.32)	0.01 (0.06)	-0.21 (-0.88)	-0.21 (-0.84)	-0.01 (-0.04)	0.02 (0.09)
wage	-0.04 (-0.63)	-0.04 (-0.56)	0.05 (0.38)	0.05 (0.39)	-0.22 (-1.8)*	-0.21 (-1.76)*
dairy profits (y^*)	-	0.21 (3.34)***	-	0.03 (0.22)	-	0.13 (1.08)
land labour ratio	0.61 (2.51)***	0.62 (2.75)***	0.06 (0.14)	0.06 (0.14)	-0.17 (-0.4)	-0.17 (-0.39)
F	1.88*	3.36***	1.21	1.04	0.9	0.94
R^2	0.09	0.24	0.02	0.01	0.00	0.00

t - values are shown in parenthesis,
a) dairy profits assumed constant,
b) dairy profits assumed variable,
***, **, * *denote significant coefficients at 1, 5 and 10 percent levels respectively.*

Similarly a separate regression of total (men, women and children) labour supply response to crop production, given changes in dairy profits, in the integrated models predicts that total supply to crop production will increase. The regressions for IVB (women supply) and IVC (children supply) are not significant and lack information (R^2=0) (Table 4.7)..

However, the sign and value of coefficient of men labour supply, 0.21, predict that total labour supply is increased to crop production (slightly) with an increase in dairy profits. The regression equation IVA (men labour supply) as can be observed from the F-ratio, is significant at the 1 percent level.

The result that CBC family members increase their labour supply to crop production is not surprising since CBC owning households have more cultivated land area than LBC owners. Moreover, the results of the demand equations show that CBC owners demand more labour for both crop and livestock production. The family labour supply response of CBC households to livestock production is negative while to crop production is positive but inelastic. This implies that such households get labour from external sources (outside of the family). Nevertheless, as Table 4.8 shows, hired labour participation is low and households meet most of the additional labour needs by exchanging labour (which is the most observed practice of overcoming labour shortages).

Table 4.8. The Mean Cost (in Birr), Family Labour Supply (in hours) and the Share of Labour Cost From the Total Cost for Crop and Livestock Production of CBC and LBC Households

Owners of	Crop production				Livestock production			
	Hired cost (Birr)	Total cost (Birr)	Family labour supply (hours)	Total labour demand (hours)	Hired labour cost (Birr)	Total cost (Birr)	Family labour supply (hours)	Total labour demand (hours)
CBC	57.30	355.60	119.30	1014.45	30.40	474.9	299.35	3444.55
LBC	79.30	149.30	50.00	226.40	34.50	150.3	628.50	2292.20

Therefore, although CBC is labour demanding and households are benefiting from the technology, the spill over effect to the rural poor (who do not adopt the technology) through employment expansion is very low.

5. POLICY IMPLICATIONS AND CONCLUSION

5.1 Policy Implications

The empirical results of this study have implications for price policy and technological change. The estimated models provide three types of information: first, responses in terms of consumption of various commodity groups; second, labour supply responses of farm families to crop and livestock production; and third, farm labour demand responses of farm households.

The results from the integrated models estimated in this study suggest that an increase in output prices, not accounting for differences in profits from dairying, decrease the consumption of both non-food and food items. However, an increase in the wage rate is unlikely to change consumption of consumable items in the study area. There is, thus, some scope for government output price policy (labour input price policy) to affect farm household consumption, a result consistent with other studies of the consumption responses of low income rural populations to changes in price and wage policies. Household labour supply response to an increase in wage rates and output prices, meanwhile, is likely to decrease labour supply marginally. The estimated labour demand equation also suggests that labour demand is unlikely to be price responsive as long as price changes take place along with technological change.

In general, changes in output prices are likely to have negative impact on consumption of food and non-food commodities of rural households whereas allocation of labour does not seem to be affected by output price changes. Price of labour (wage) is also unlikely to affect household labour allocation and consumption.

With regard to the policy implications of technological change on consumption and labour allocation, the results of farm household response provide considerable insight. An increase in profit resulting from introduction of dairy production technology has significant and positive consumption effects particularly on dairy products; the impact on labour allocation is also significant.

The estimated equations show that the elasticities of labour demand are higher than the supply of household labour. The demand for labour both for crop and livestock production increases, but the supply of household labour, in general, decreases marginally. The response to crop production is slightly positive. The slack is not, however, taken up by increasing the hiring in of labour. It is usually obtained through labour exchange arrangements. Households who get labour from external sources might give their oxen to external labour suppliers to use it in return for their labour. Nevertheless, this study can not adequately predict the likely effects of the technology on wage farm employment since the study does not fully cover how rural factor markets operate. Moreover, implication of the technology on labour supply of men and women to livestock production as well as labour supply of children and women to crop production are not predicted explicitly.

5.2 Conclusions

This study extends the theory of agricultural household models to a multi-crop and mixed farming (crop and livestock production) environment of the North-western Zone of Shoa. The study has attempted to indicate the impacts of changes in dairy production technology, output prices and wage rate on consumption and household labour allocation.

The results of this study complement the implications of research on irrigation technology change in Gambia in improving dairy profit and household consumption, as well as in increasing labour demand. In contrast with the results in Gambia, labour supply of men also increases, but hiring in of wage labour (paid in cash) is not expected to occur. Moreover, unlike results from Korea, Nigeria and Malaysia, the positive dairy profit effects is not strong enough to offset the negative own-price effects on consumption. Nevertheless, the results of this study showed those with higher dairy profits (CBC households) consumed more of most consumption items.

With regard to labour allocation, like the results in Malaysia, labour demand was found to be highly responsive to technology, and less responsive to wage rate. Household labour supply to farming was found to decrease, but marginally. Unlike results from Malaysia, labour supply was found not to be responsive to output price.

The methodological procedure used to model agricultural households has some limitations. The assumption of risk free production, homogenous market products and single food prices, and single market wage rate for labour were made to simplify the analysis using the household framework. The assumption of risk free production is particularly strong where farm households practice inter-cropping as a risk averting strategy.

Data on LBC owners for values of most of the variables is based on extrapolations from a short survey period and a relatively small sample size. Data on prices of outputs were also from one particular region (where variability could not be observed). The limitation of data reliability could be improved by collecting data for one year in different regions (or market areas) from larger sample sizes.

In spite of all these limitations of the study, the predictions of household consumption and labour allocation responses made using the framework were insightful. Further research would help to resolve the questions of what household response would be to different kinds of risk, wage rates for various categories of labour (by sex and age), differences in farm gate and retail prices of food, and examine the assumption of profit maximization under the condition of inter-linked factor markets.

NOTES

[1] Leisure consumption of the family as well as total family and hired labour input in to crop and livestock production are valued at the market wage (see Singh and Janakiram, 1986).

[2] Barnum and Squire (1979) noted that the results of the estimated leisure functions are quite sensitive to the length of working day (see Barnum and Squire, 1979).

[3] The correlation between dairy profit and profit from crop production is 0.03. The square of this correlation value can serve as a rough estimation to indicate the proportion of the variation in dairy profit explained by variation in profit from crop production.

[4] For the details of the basic factors that affect the supply of labour (see Raffin and Gregory, 1983).

[5] It is believed that amount of labour each member of the household contributes to crop production varies by age, sex and working condition of each member in the household. Working condition of members refer to the fact that family members working greater (less) than the annual average working hours required in the farm are referred to as 'full-time workers' (part-time workers). Members can be part-time workers because of many reasons: farmers with other social and administrative responsibilities; housewives; students; traders; house maids; etc. The coefficients for converting household labour into man equivalents (standard labour units) by age and sex categories are shown in Appendix 1.

[6] The correlation of dairy profits with the technology dummy variable was found to be high and significant at the 1 percent level. Therefore to avoid multi- collinearity in the estimated equations, dairy profit is assumed to capture the effect of dairy technology.

REFERENCES

Abate Tedla, (1987) 'Economic Evaluations of Improved Vertisol Drainage for Food Crop Production in the Ethiopian Highlands' in I. Hague et al. (Eds.) (1987), ***Management of Vertisols in Sub-Saharan Africa,*** Proceedings of ILCA Conference on Management of Vertisols in Sub-Saharan Africa, Addis Ababa.

Abbott, P. and M. Roth, (1983) 'The World Grain Sorghum and Millet Economics', ***Station Bulletin*** No. 416, Department of Agricultural Economics, Indiana: Purdue University.

Abebe Zerihun, (1989). ***Income Distribution and Consumption Patterns in Rural Ethiopia: A Statistical Analysis of Family Budgets***, M.Sc. Thesis, Department of Economics, Addis Ababa University. (unpublished).

Anon, (1986). ***Cattle Breeding Policy of Ethiopia***. Addis Ababa: MoA.

Baker, D. C. and C. K. Eicher, (1982) 'Research Agricultural Development in Sub-Sahara Africa: A critical Survey', ***Development Paper No. 1***, Department of Agricultural Economics, East Bansging, Michigan: Michigan State University.

Barnum, H. N. and L. Squire, (1979) 'A model of an Agricultural Household: Theory and Evidence', ***World Bank Occasional Paper***, No. 27, Washington D.C.

Bekele Shiferaw, (1991). ***Crop-livestock Interaction in the Ethiopian Highlands and Effects on Sustainability of Mixed Farming: A Case Study From Ada District***, M.Sc. Thesis, Agricultural University of Norway.

Binswanger, H. P. and von Braun J., (1991). Technological Change and Commercialization in Agriculture: The Effect of the Poor, ***The World Bank Research Observer***, Vol. 6, No. 1.

Boodt, K. and G. Gryseels, (1986) 'Integration of Crossbred Cows (Boran X Friesian) on Smallholder Farms in the Debre Zeit Area of the Ethiopian Highlands,' ILCA.

Carr, M. and G. L. Scott, (1985). The Impact of Technology Choice on Rural Women in Bangladesh: Problems and Opportunities, ***World Bank Staff Working Papers No. 731***, Washington D.C: The World Bank.

Casley, D. J. and K. Kumar, (1988). ***The Collection, Analysis and Use of Monitoring and Evaluation***

Data, A Baltimore: The John Hopkins University Press.

Central Statistical Authority, (1988) 'Average Retail Prices of Goods and Services in Rural Areas by Region, *Statistical Bulletin* No. 64.

____, (1990). 'Average Retail Prices of Goods and Services in Rural Areas by Region', ***Statistical Bulletin* No. 83.**

____, (1991). 'Average Retail Prices of Goods and Services in Rural Areas by Region', ***Statistical Bulletin* No. 96.**

____, (1992). Average Retail Prices of Goods and Services in Rural Areas by Region, ***Statistical Bulletin* No. 106.**

____, (1992) 'Average Retail Prices of Goods and Services in Rural Areas by Region', ***Statistical Bulletin* No. 107.**

____, (1993) 'Average Retail Prices of Goods and Services in Rural Areas by Region', **Statistical Bulletin No. 115.**

Ellis, Frank (1988). **Peasant Economics: Farm Households and Agrarian Development** Cambridge: Cambridge University Press.

Gashaw Geda et al., (1991) ' Smallholder Dairy Production in Northern Shoa Province, Central Highlands of Ethiopia: Feeding Management and Performance of Friesian X Zebu (Boran) Crossbred Dairy Cows', in T. Varvikko (ed.). **Development of Appropriate Feeding systems for Dairy Cattle in the Ethiopian Highlands.** Addis Ababa : ILCA.

Gould, J.P. and E.P. Lazear (1989). **Microeconomic Theory, 6th edn.**, Delhi: Vikas Publishing.

Gryseels G. (1988). **Roles of Livestock on Mixed Smallholder Farms in the Ethiopian Highlands,** PhD. Dissertation, Agricultural University, Wageningen, The Netherlands.

Gryseels, G. and F.M. Anderson, (1983) 'Research on Farm and Livestock Productivity in the Central Ethiopian Highlands; Initial Results, *1977-80'*, ***Research Report No.4,*** ILCA, Addis Ababa.

Hazell, P.B. and A. Roell, (1983) 'Rural Growth linkages: Household Expenditure Patterns in Malaysia and Nigeria', **IFPRI Report No. 41.**

Honthakker, H.S. and S.J. Prais, (1971). ***The Analysis of Family Budgets.*** Cambridge: Cambridge University Press.

IBRD, (1981). ***Accelerated Development in Sub-Saharan Africa: An Agenda for Action***.Washington D.C.: The World Bank.

Jiggins, J., (1986) 'Gender-related Impacts and the Work of International Agricultural Research Centers', **CGIAR Paper No. 17**, The World Bank, Washington DC.

Kiwuwa, et al., (1983) 'Crossbred Dairy Cattle Productivity in Arsi Region of Ethiopia', ***Research Report***, No. 11, ILCA, Addis Ababa.

Lale, Uma, (1986) 'Women and Structural Transformation', ***Economic Development and Cultural Change***, Vol. 34, (January).

Lawani, M., (1990) 'Human Labour Absorption in Dairying: Evidence from Karnal Villages of Haryana', ***Indian Journal of Agricultural Economics***, Vol. XLV, No. 2.

Lawrence, P.G., S. Rameswamy and J. H. Sanders, (1983) 'Technological Change in Agriculture and the Welfare of Sahelian Women: A Case Study in Burkina Faso', in J. H. Sanders, Sunder Ramaswamy, and B. I. Shapiro (eds.). ***The Economics of Agricultural Technology Development in Sub-Saharan Africa.*** Baltimore: The John Hopkins University Press.

Lipner, M. E. and B. I Shapiro, (1992) 'Gender and Technology Research in Africa', ***Proceedings of the All-Africa Conference on Animal Agriculture***, Nairobi.

Lundstrom, T.G., (1991a) 'Performance of Crossbred Dairy Cattle in Northern Shoa of Ethiopia', ***Monitoring and Evaluation Report*, No. 5**, MoA, Addis Ababa.

______. (1991b) 'Feeding and Management of Crossbred Cattle on Project Contact farm', ***Monitoring and Evaluation Report* No.3**, Addis Ababa.

Massow, V. H. Von, (1989) 'Dairy Imports into sub-Saharan Africa: Problems, policies and prospects', **Research Report, No. 17**, ILCA, Addis Ababa.

Michael, H., (1985) 'Rural Energy Survey in the Third World: A Critical Review of Issues and Methods', Canada, IDRC.

Ministry of Agriculture, (1987). ***National Breeding Policy on Dairy Cattle***. Addis Ababa: MoA.

____, (1989). **Selale Peasant Dairy Development Pilot Project (SPDDPP): Base Line Survey.** Addis Ababa: MoA.

____, (1991) 'SPDDPP: Milk Utilization on Project Conduct Farms', ***Monitoring and Evaluation Report*, No. 8**, Addis Ababa.

Nicholson, W. (1992). ***Microeconomic Theory: Basic Principles and Extensions*, 5th ed.**, USA.

Olsson, A., (1986) 'Performance of Dairy Cattle at the Research and Dairy Co-operative Farms in the Arsi Region of Ethiopia', ***Working paper* No. 39**, Uppsala: International Rural Development Center.

Pitt, M. Mark and Mark Rosenzweig (1986) 'Agricultural Prices, Food Consumption and the Health and Productivity of Indonesian Farmers', in J. Singh, L. Squire and J. Strauss (eds.). ***Agricultural Household models: Extensions, Application and Policy***, Baltimore: John Hopkins University Press.

Raffin, R. J. and P. R. Gregory, (1983). ***Principles of Economics***. U.S.A: Scott, Forman and Company.

Savadogo, K., (1980). ***An Analysis of the Economic and Socio-demographic Determinants of Household Food Consumption in Ouagadaugou Burkina Faso***, Ph.D. Thesis, Purdue University, (unpublished).

Schaar, J. et al., (1981) 'Breeding Activities of the Ethio-Swedish Integrated Rural Development Project: Milk Production of Zebu and Crossbred Cattle', ***World Animal Review, No.37***.

Schmidt, P. et al., (1981) 'Joint Determination of Food Consumption and Production in Rural Sierra Leone: Estimates of a Household - Firm Mode l, ***MSU Rural Development Series, Working Paper No. 17***, Michigan.

Singh, I. and S. Janakiram, (1986) 'Agricultural Household Modeling in a Multi-crop Environment: Case Studies in Korea and Nigeria' in I. J. Singh, L. Squire and J. Strauss (eds.). ***Agricultural Households Models: Extensions, Applications and Policy***. Baltimore: John Hopkins University, Press.

Singh, I., L. Squire and J. Strauss, (1986). ***Agricultural Household Models: Extensions, Applications and Policy***: Baltimore : John Hopkins University Press.

Strauss, John, (1986) 'Estimating the Determinants of Food Consumption and Caloric Availability in Rural Sierra Leone', in I. J. Singh, L. Squire, and J. Strauss (eds.). ***Agricultural Household Models: Extensions, and Policy***. Baltimore: John Hopkins University Press.

Thomas, R. L., (1993). ***Introductory Econometrics: Theory and Applications, 2nd ed.*** New York. Longman.

Tshibaka, T. B., (1992) 'Labour in the Rural Household Economy of the Zairian Basin', ***Research Report* No. 90.**, IFPRI.

Varvikko, Tuomo, (1991) 'Development of Appropriate Feeding systems for Dairy Cattle in the Ethiopian Highlands', ***Final Report***, ILCA, Addis Ababa.

von Braun, J., (1988) 'Effects of Technological Change in Agriculture on Food Consumption and Nutrition: Rice in West African Setting', ***World Development***, 16 (9).

von Braun, J., D. Puetz and P. Webb, (1989) 'Irrigation Technology and Commercialization of Rice in The Gambia: Effects on Income and Nutrition', ***Research Report* No. 75**, IFPRI, Washington D.C.

Waters-Bayer, A., (1984) 'Women as Decision Maker in Dairying, Workshop on Women and Agriculture in West Africa', ILCA, Ibadan.

APPENDIX 1

Table 1.1 FAO/WHO coefficients for converting family size into standardized household size.

Age Category (Years)	Sex		
	Male	Both	Female
< 1		0.4	
1-3		0.6	
4-6		0.8	
7-9		0.9	
10-12	1.1		1.0
13-15	1.0		0.9
16-19	1.0		0.8
20-39	1.0		0.8
40-49	1.0		0.7
50-59	0.9		0.7
60-69	0.8		0.6
≥ 70	0.7		0.5

Source: Michael (1985)

Table 1.2 Coefficients for converting household labour into a standard labour unit.

Sex/age category	Condition	Labour unit
< 8 or >75		
Children (8-14)		
Children (8-14)		
Adult male (15-65)	1	
Adult male (15-65)	2	
Old men (66-75)		
Old men (66-75)		
House wives (15-65)	2	
House wives (66-75)	2	
Adult females (15-65)	1	
Adult females (15-65)	2	
Old women (66-75)	1	
Old women (66-75)	2	

Condition 1 refers to 'full-time worker' and condition 2 refers to 'part-time worker'.
Source: Bekele (1991).

Table 1.3 Definition of commodity groups.

Commodity sub-group	Components
1. Major staple crops	Barley, *teff* and wheat
2. Other crops	Horse beans, temenze, sorghum, haricot beans, oats, maize, lentils, sunflower, nough, linseed, chickpea, rough peas, fenugreek, field peas, millet, hopes, vegetables, fruits, spices and coffee.
3. non-dairy livestock and L.S.P: and livestock products	Meat, egg, hides and skin
4. non farm goods and services	Cooking oil, sugar, salt, Household goods, kerosene, soap, clothing, services (health, education, transport, milling), social commitments (wedding, baptism, etc.)
5. Milk	
6. Butter	
7. Cheese	
8. Leisure	All non own farming and marketing activities

Table 1.4: Mean values and coefficients of variation (cv) of consumption of various groups of commodities (in Birr) for LBC owners, CBC owners and both groups of households.

Consumption items	Consumption (in Birr)*		
	LBC owners	CBC owners	Both LBC and CBC owners
Major staple crops (Barley, teff & wheat)	108.25 (0.64)	313.040 (0.67)	2107.80 (0.88)
Other crops	614.55 (0.55)	1514.15 (0.78)	1064.35 (0.91)
Non-dairy livestock and livestock products	262.50 (0.91)	269.25 (1.04)	265.90 (0.97)
Non farm goods and services	670.95 (0.42)	885.55 (0.47)	778.25 (0.48)
Milk	64.10 (1.28)	126.45 (1.01)	95.25 (1.17)
Butter	148.05 (1.31)	355.35 (0.66)	251.70 (0.95)
Cheese	48.85 (2.13)	107.90 (1.02.)	78.35 (1.41)
Leisure	113.75 (0.60)	88.00 (0.83)	100.85 (1.0)
Total consumption	3000.80 (0.36)	6600.05 (0.41)	4800.45 (0.57)
Number of observation	30	30	60

* The values in parenthesis are coefficients of variation

Ethiopian Journal of Economics, Volume V, No. 1, April 1996, 101-103

BOOK REVIEW

Berhanu Abegaz (ed.), Essays on Ethiopian Economic Development. Aldershot: Averbury, 1994. xv+341pp. $45 hardback.

This book is an important contribution to study of the Ethiopian economy. It contains seven essays, three of them written by the editor. Three of the chapters deal with industrialization, one with agriculture, two with economy-wide issues, and one chapter attempts to set the articles in a wider global and African context. Written exclusively by Ethiopians (living abroad), it has the advantage of being up-to-date in the use of current literature although it lacks connection to the concrete situation and unpublished works in Ethiopia.

The first chapter, by Berhanu Abegaz, discusses 'the challenge of arrested development' and attempts to place Ethiopian development problems within the broader framework of African crisis. In this attempt, he notes two contending views: the ECA view which says the problems are structural and the Bank/Fund view which basically says that the problem is one of policy. However, he not only omits a third view, associated with Lawrence (1986), Harris (1986), Onimode (1988), Sutchliffe (1986), etc., which states that the problem is systemic, and fails to take advantage of this insight, but also fails to discuss the root causes of the African economic crisis (why structural/policy problems do exist). The latter would have given an important insight towards a possible solution. However, he rightly poses the interesting question of to what extent multilateral 'donors' can shape political process and the ECA analysts shy away from the logical implication of their analysis.

The second chapter by Berhanu Nega deals with economy wide issues by constructing a Kalecki-FitzGerald inspired macroeconomic model. The author notes that both his theoretical and empirical analysis suggest the difficulty of rapid accumulation (and hence growth) in what he calls the 'Open Peripheral (dependent) Socialist Economy'. Closer examination of the assumptions and the structure of the model reveals that the conclusions are not warranted. For instance, the author assumes, a) that agricultural output market is not flexi-price based, and b) that investment (not output) adjusts to the foreign exchange constraint. These assumptions not only diverge from major stracturalist assumption but also do not tally with the stylized facts in Ethiopia. As to the first assumption, peasants had been marketing a good portion of their output in the flexi-price market (the marketing board procurement was only a part of it). The second assumption is also unrealistic as most industries were extremely import dependent and import compression (with its adverse effect on capacity utilization and output) was the rule. Another major limitation of the model relates to the center of accumulation. Reading this chapter one would expect the state to be the main center of accumulation. The 'socialist' state of Ethiopia was doing that although the mode of utilization had problems. That analysis is missing in this study, and in I believe this is a major shortcoming of any analysis which claims to depict a 'socialist' economy.

Berhanu Abegaz, Roman Habtu and Mulatu Wubneh discuss the industrial sector in three chapter of the book. Each starts by giving an excellent, concise survey of the theoretical literature. Berhanu discusses the different stages of manufacturing and attempts to relate this to Ethiopia. His analysis culminates by suggesting an agro-industry based industrialization carried by a partnership of the state and the private sector. There are two fundamental problems with his analysis. First, he tacitly accepts the *status quo*, that is, he doesn't question the disarticulation of the domestic production and consumption structure and attempt to see the stages of industrialization as it is –from the nature of the urban pattern of consumption. This fundamental neglect is reflected by lack of discussion about the industry-agriculture linkage, which is central for any industrialization analysis in Ethiopia. A related major problem in his discussion of stages of industrialization is lack of a dynamic mechanism that governs the industrialization process from the beginning to the end (this reminds one of Rostow's stages of development and its Marxian variant). Lack of such dynamic linkage is reflected in his empirical work.

Roman Habtu (chapter 5) discusses the situation of small-scale industries. By analyzing the current situation she argues for an industrial strategy which will be based on the idea of 'industrial district'. As is the case

BOOK REVIEW

Berhanu Abegaz (ed.), Essays on Ethiopian Economic Development. Aldershot: Averbury, 1994. xv+341pp. $45 hardback.

This book is an important contribution to study of the Ethiopian economy. It contains seven essays, three of them written by the editor. Three of the chapters deal with industrialization, one with agriculture, two with economy-wide issues, and one chapter attempts to set the articles in a wider global and African context. Written exclusively by Ethiopians (living abroad), it has the advantage of being up-to-date in the use of current literature although it lacks connection to the concrete situation and unpublished works in Ethiopia.

The first chapter, by Berhanu Abegaz, discusses 'the challenge of arrested development' and attempts to place Ethiopian development problems within the broader framework of African crisis. In this attempt, he notes two contending views: the ECA view which says the problems are structural and the Bank/Fund view which basically says that the problem is one of policy. However, he not only omits a third view, associated with Lawrence (1986), Harris (1986), Onimode (1988), Sutchliffe (1986), etc., which states that the problem is systemic, and fails to take advantage of this insight, but also fails to discuss the root causes of the African economic crisis (why structural/policy problems do exist). The latter would have given an important insight towards a possible solution. However, he rightly poses the interesting question of to what extent multilateral 'donors' can shape political process and the ECA analysts shy away from the logical implication of their analysis.

The second chapter by Berhanu Nega deals with economy wide issues by constructing a Kalecki-FitzGerald inspired macroeconomic model. The author notes that both his theoretical and empirical analysis suggest the difficulty of rapid accumulation (and hence growth) in what he calls the 'Open Peripheral (dependent) Socialist Economy'. Closer examination of the assumptions and the structure of the model reveals that the conclusions are not warranted. For instance, the author assumes, a) that agricultural output market is not flexi-price based, and b) that investment (not output) adjusts to the foreign exchange constraint. These assumptions not only diverge from major stracturalist assumption but also do not tally with the stylized facts in Ethiopia. As to the first assumption, peasants had been marketing a good portion of their output in the flexi-price market (the marketing board procurement was only a part of it). The second assumption is also unrealistic as most industries were extremely import dependent and import compression (with its adverse effect on capacity utilization and output) was the rule. Another major limitation of the model relates to the center of accumulation. Reading this chapter one would expect the state to be the main center of accumulation. The 'socialist' state of Ethiopia was doing that although the mode of utilization had problems. That analysis is missing in this study, and in I believe this is a major shortcoming of any analysis which claims to depict a 'socialist' economy.

Berhanu Abegaz, Roman Habtu and Mulatu Wubneh discuss the industrial sector in three chapter of the book. Each starts by giving an excellent, concise survey of the theoretical literature. Berhanu discusses the different stages of manufacturing and attempts to relate this to Ethiopia. His analysis culminates by suggesting an agro-industry based industrialization carried by a partnership of the state and the private sector. There are two fundamental problems with his analysis. First, he tacitly accepts the *status quo*, that is, he doesn't question the disarticulation of the domestic production and consumption structure and attempt to see the stages of industrialization as it is –from the nature of the urban pattern of consumption. This fundamental neglect is reflected by lack of discussion about the industry-agriculture linkage, which is central for any industrialization analysis in Ethiopia. A related major problem in his discussion of stages of industrialization is lack of a dynamic mechanism that governs the industrialization process from the beginning to the end (this reminds one of Rostow's stages of development and its Marxian variant). Lack of such dynamic linkage is reflected in his empirical work.

Roman Habtu (chapter 5) discusses the situation of small-scale industries. By analyzing the current situation she argues for an industrial strategy which will be based on the idea of 'industrial district'. As is the case with the other articles (chapter 4, for instance) the industrial district concept is hardly connected with the dynamics of agriculture. For example, she suggests, perhaps rightly, sub-contracting as an important option for small-scale industries. This inevitably assumes the existence of large-scale industries *ex-ante*. However, the decision about the latter cannot be envisaged independent of a general macro-analysis with particular attention to the industry-agricultural link. If one starts from this rather broader issue, her micro suggestion may not be substantive (for example, if small rural based industrialization is the policy regime at the outset). This failure to integrate the micro analysis with the macro framework and explore their dynamic linkage leads her to propose contradictory policies. For instance (p. 246) she suggests preferential treatment for small-scale industries in financial policy. However, she earlier proposed that the small-scale industries be engaged in sub-contracting. The latter implies having large-scale industries which themselves need preferential treatment.

Both Berhanu's and Roman's article ignore the cultivation of domestic technological capability (say through horizontal linkage and linkage to technology centers -the creative attempt by Ghanaians to create a link between universities and productive firms is a case in point). As a result, technology transfer, which is central in industrialization, is envisaged only through foreign exchange generation (which is not analyzed anyway). The main point one should note from the readings on industry is that the old agriculture versus industry debate is still with us although we attempt to diffuse it by splitting the question into its constituent parts. Thus, in order to say something about the industrial sector as well as to discuss the details of any policy prescription regarding industrialization, we need to logically and empirically articulate the industry versus agriculture question first.

Mulatu Wubneh (chapter 6) discusses the productivity of the manufacturing sector from 1960-88. Mulatu gives an excellent picture of the history of manufacturing. He also includes interesting time series data, which is unusual in most published works. He makes an empirical analysis of productivity by employing Cobb-Douglas (CD) and translog functional forms. However, a major problem in his analysis is that he tries to study productivity over a period of time, which is a dynamic phenomena, using a static framework (CD) exclusively designed for efficiency analysis. Following his methodology one might obtain a snapshot picture of the (average) points in the two periods of analysis but not the process in each of the periods-which I think is fundamental for studying structures (the variation in institutional framework in the two periods is a case in point).

Mesfin Mirotchie's article (chapter 4) is the only article about the agriculture sector. Mesfin attempts to investigate the technical efficiency of agriculture using Cobb-Douglas and translog functions. He concludes that the private farm sector is efficient in the allocation of resources while that of state farm is not. The later is attributed to poor policy. However, there are some problems with his study. First, the title is very wide, yet low land areas and pastoral farmers are completely left out of the analysis. Second the price used for the analysis of the private farm sector is not a good proxy. It would have been best reflected by taking the weighted average of marketing board's (AMC) and parallel market price and its regional variation.

One of the major problems of Mesfin's model is the use of the production functions which assume substitution among the arguments. Such functions suit situations where the search for efficiency is done under a context of competitive market. This situation does not fit the agricultural sector in Ethiopia and makes one wonder whether such a search for efficiency is worth pursuing. Instead, a search for a dynamic process which changes the structure of the agricultural sector, even if that does mean inefficiency in the short run, might be relevant. This, I believe, is an important point in analyzing the agricultural policy in Ethiopia and is not considered by Mesfin. As a result, some of his results stand in striking contrast to studies carried out by researchers working in Ethiopia. Such perverse results are partly the consequence of the restrictive nature of the functional forms adopted.

A common problem in most of the chapters is that some of the figures are not correctly cited. Sometimes evidence is incorrectly interpreted. Moreover, in some of the articles the econometric analysis is very weak and lacks formal diagnostic testing, especially of spurious regression in the time series studies.

The final chapter, by Berhanu Abegaz, attempts to summarize the current reform of the Ethiopian government by relating it to the literature on economic reforms. In discussing the role of the state he raises

Notes to Contributors

STYLE AND FORMAT FOR EJE PUPLICATIONS

1. Draft articles for publication in the EJE are sent to the editor in triplicate, typed double-spaced and on one side only of an A4-size paper. It should also be accompanied by an electronic version. Although no strict limits are imposed on the size of on an article, current editorial policy limit this to a maxim of 30-40 pages (for text only).

2. An article submitted to the EJE has the following features:

i. On the front page: Title, Author's full name (plus affiliation and acknowledgments if any), the Abstract (in single space and in not more than 100 words), and a portion of the text.

ii. The article is divided into sections and sub-sections, sequentially arranged and numbered (using Arabic numerals), followed by Notes, References, and Appendices.

3. Diagrams should be properly labeled and carefully drawn, and preferably kept in a form suitable for photographic reproduction. Tables too are sequentially numbered with a descriptive heading and kept within the space provided in a page (at the most). Details of mathematical and statistical work in support of the publishable portion of the manuscript should also be sent to the editor for use by the referees.

4. All manuscripts should be submitted with a statement by each author explaining the status of the manuscript, i.e. whether or not it is published (or submitted for consideration) elsewhere.

5. Copyright of accepted articles is vested with the Ethiopian Journal of Economics.

Detailed style and format can be obtained from EEA.