

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

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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

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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 assess 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 continuous 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 assess 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

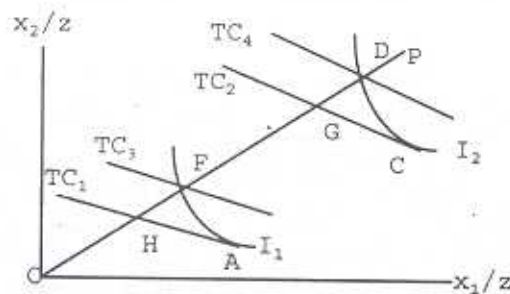
The traditional economic theory of the firm which presupposes technical efficiency and/or perfect and free information, pushes aside the matter of inefficiency by neglecting the role of education or the differences in human factor from the analysis of production. However, various recent studies revealed 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 (1) 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 TC_1 (which represents the minimum cost level) depicts the most efficient production point.

Fig. 1. Allocative and Technical Efficiency in the Case of One Output 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 I₂ is tangent to the total variable cost line TC₂. Thus, a farm that operates at point D is allocatively inefficient by the cost gap TC₄-TC₃. 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 I₁, 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 $X = (x_1, x_2, \dots, x_n)$, and m fixed inputs $Z = (z_1, z_2, \dots, z_m)$ and a vector of expected prices for variable inputs $W = (w_1, w_2, \dots, w_n)$ the maximum attainable output is given by $f(X, Z)$, and then the maximum restricted profit (total revenue less variable cost only) will be $\Pi(P, W, Z) = \max_{Y, X} \{PY - W'X / f(X, Z) \geq Y, X \geq 0, Y \geq 0\}$ where P is the price of the output Y (Forsund *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 such 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,

$$\ln \Pi = \ln \alpha_0 + \delta^1 D^1 + \beta_i \ln W_i + \gamma_j \ln Z_j + U_i \tag{1}$$

$$\frac{-W_i X_i}{\Pi} = \beta^*_1 D^1 + \beta^*_2 D^2 + V_i, \quad i = 1, 2, \dots, n \tag{2}$$

Where:

- Π_i = restricted profit
- W_i = variable input prices
- Z_j = fixed inputs
- D^1 and D^2 = some different characteristics of farmers such as small and large, or literate and illiterate, etc...
- i = the i^{th} house hold

$\alpha_0, \delta, \beta_i, \gamma_j, \beta^*_1$ = coefficients 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 be 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).
- iii. *Equal economic efficiency:* This involves testing equal relative and allocative efficiency.

- iv. *Absolute allocative efficiency*: This tests which groups of farmers achieve 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 (Pudasani, 1983).

The use of the profit function model is not, however, without limitations. As argued by Aigner, Lovell and Schmidt (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 overcome 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' (Førsund *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, $W^1 X^1 > C(Y^1, W, Z^1)$ and the corresponding profit level will be less than the maximum and is given by $(PY^1 - W^1 X^1 / Z^1) < \Pi(P, W, Z^1)$ (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, $W^1 X^1 > C(Y^1, W, Z^1)$ and $(PY^1 - W^1 X^1 / Z^1) < \Pi(P, W, Z^1)$. Førsund *et al.* (1980) indicated that 'Observed expenditure $W^1 X^1$ 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:

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

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.

Define $\varepsilon_{it} = U_{it} + V_{it}$ [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' $Y_{it} = b_0 \Pi(X_{ijt})^{bj} e^{\varepsilon_{it}}$, (Dawson *et al*, 1991).

Thus, the above equation can be written as

$$Y_{it} = b_0 \Pi(X_{ijt})^{bj} e^{(U_{it}+V_{it})} \quad [5]$$

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

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

Where

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

Based on this basic principle various researchers tried to measure not only technical efficiency which is given by $e^{U_{it}}$ 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 Sri 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 Forsund *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 Forsund, *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

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

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 whether 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 concluded 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 ploughing, 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).

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

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
 $\alpha_0, \beta_j,$ 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; $H_0: E[U]=0$
2. If there is profit inefficiency in the sampled farmers it arises by chance:

$$H_0: \gamma = \frac{\sigma_U^2}{\sigma_U^2 + \sigma_V^2} = 0$$

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_U^2 , 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
$\sigma^2 = \sigma_u^2 + \sigma_v^2$			1.1122** (1.5214)
$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$			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.

$$\ln \Pi_i = \alpha_0 + \delta^L D_{ik}^L + \sum_{j=1}^2 \beta_j \ln w_{jk} + \sum_{j=1}^2 \gamma_j \ln Z_{jk} + \alpha_1 D_{ik} + \beta_{\lambda 1} \lambda_{ik} + V_{ik} \dots [2]$$

$$\frac{-W_1 X_1}{\Pi_1} = \beta_1^L D_{ik}^L + \beta_1^I D_{ik}^I + \beta_{\lambda 2} \lambda_{ik} + \varepsilon 1_{ik} \quad [3]$$

$$\frac{-W_2 X_2}{\Pi_1} = \beta_2^L D_{ik}^L + \beta_2^I D_{ik}^I + \beta_{\lambda 3} \lambda_{ik} + \varepsilon 2_{ik} \quad [4]$$

Where:

- K is 1 or 2 based on whether education is defined as literacy level or primary education, respectively
- j is the jth input and i is the ith 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,
- $\alpha_0, \alpha_1, \delta^L, \beta_{j, \gamma}, \beta_{\lambda j}, \beta_{\lambda i}^L$, and $\beta_{\lambda i}^I$ 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	
Illiterate 2	-0.0167 (0.137)
λ_2	-0.1118 (0.648)
Model Test F[2,117]	-0.0570 (0.365)
	9.75
3. The fertiliser demand function	
Educated 2	
Illiterate 2	-0.0679* (2.187)
λ_3	-0.0564 (1.295)
Model Test F[2,117]	-0.5738 (1.444)
	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: $\delta^L = 0$, $\beta^L_1 = \beta^1_1$, and $\beta^L_2 = \beta^1_2$
3. Educated and uneducated farmers have *equal relative allocative* efficiency in utilisation of hired labour and fertiliser inputs:
Ho: $\beta^L_1 = \beta^1_1$ and $\beta^L_2 = \beta^1_2$
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: $\beta_1 = \beta^1_1$ and $\beta_2 = \beta^1_2$

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 1 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^L_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^L_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 ^a	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-I. 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.

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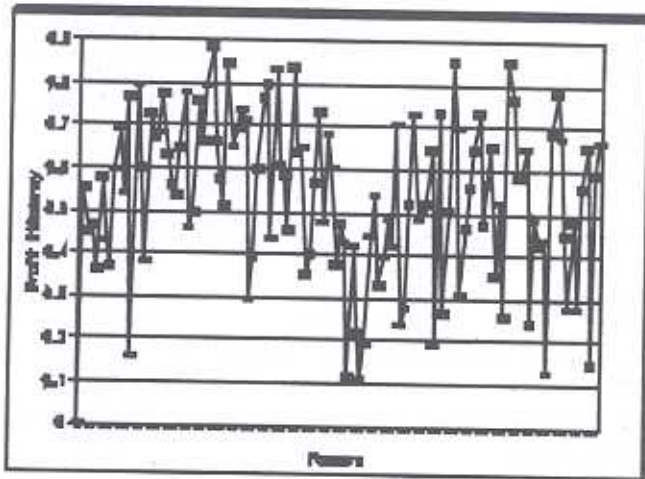
Appendix I: Probit Analysis: Determinants of Fertiliser and Hired Labour Inputs Usage

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	A ₀	-1.0726* (3.903)
log likelihood function		-186.4687
Restricted log likelihood		-212.1693
Pseudo R ² = 1 - $\frac{\text{loglikelihood}}{\text{restricted likelihood}}$.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