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

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ABSTRACT

With the growing interest in human capital theory, analyzing the impact of education on efficiency has been given special emphasis. This study first testes the celebrated hypothesis that 'traditional farmers are efficient but poor'. The result of the stochastic profit frontier function does not support this hypothesis in the Ethiopian case. The result shows 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. This implies that there is 46.0 percent profit inefficiency in the sampled farmers. Next it is tried to test the hypothesis of equal allocative and technical efficiency of educated and illiterate farmers by using the modified Y-L profit function model under various linear restrictions. The results reveal 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 expanding education and consequently by making illiterate farmers to operate closer to the efficiency level achieved by their educated neighbors. It is also shown that education increases not only the efficiency of farmers but also the probability of farmers to adopt improved inputs such as fertilizer. The multinomial probit analysis also shows that education and environment variables are substitutes in modern areas and complementary in traditional environments. This suggests that expansion of schools and increasing enrollment rates in rural areas have higher pay off than in modern areas at least in increasing the probability of farmers to adopt fertilizer input.

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CHAPTER ONE

INTRODUCTION

1. 1. BACKGROUND

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 analyze 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, defined broadly as 'all deliberate learning activities', is usually used as an approximation to Human Capital. That is why most of the studies in the area of human capital use formal education (usually years of schooling) and informal education (age, experience, number of contacts between extension worker and farmers, etc.) to analyze the contribution of human capital to growth.

In Ethiopia modern formal education is of recent origin. There was no modern school in the country until the first school, Menelik II school, was opened in 1908 in Addis Ababa. In fact the growth of education in the country was very sluggish until 1942 (the restoration of independence) and its over all development is still very low by most international standards.

The agricultural sector which provides directly or indirectly the livelihood for more than 90% of the population, generates nearly half of the GDP, and contributes for more than 90% of the total export revenue, is also at a very low level of development. Its production system is backward and the production technologies are one of the most traditional in the world [Assefa,1995,p.1]. The only principal inputs are labour and land and the application of modern inputs is very minimal. Regarding this situation Bisrat Aklilu wrote:

> The absence, or at best, minimal use of purchased, yield increasing inputs has resulted in a traditional production method. The oxen drawn wooden plough which dates back to Biblical days and a few other simple implements usually constitute the farmer's entire capital stock [Bisrat, 1976, p.1].

Education is hypothesized to affect agricultural productivity at least in two different ways. First of all, 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 analyze information and to adjust quickly to disequilibria. As a result, 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.

Though it is small by international standards, on the average 12% of the total government expenditure has been allotted to the educational sector in the past quarter of the century. According to 1993/94 data a total of 3 million students were enrolled in 8674 primary, 1167 junior secondary and 303 senior secondary schools [MOA, Education Statistics].

One important issue that arises at this juncture is to know the contribution of education to the development of the economy specially to the agricultural sector which is the backbone of the Ethiopian economy. Various studies conducted in low income countries revealed that education (both formal and informal) enhances agricultural productivity. This study is expected to add some findings to the accumulated knowledge in these areas.

The organization of the study is as follows. Chapter two presents briefly an overview of the Ethiopian educational sector, its present status and the associated problems. The third chapter is devoted to the review of the theoretical and empirical works done in the area of education and efficiency. The data base and the methodology of the study are presented in the fourth chapter. The fifth chapter deals with the empirical findings of the study and the last chapter presents the conclusions and recommendations of the study.

1.2. STATEMENT OF THE PROBLEM

> "Education in Ethiopia can't be considered as end set apart from the general requirements of socio-economic development. It has primarily to serve the needs of the country's development and this makes its fullest contribution to the achievement of national goals".

Imperial Ethiopian Government Second Five-Year Plan,1963-1967

> "There will be an educational program that will provide free education, step by step to the broad masses. ... All necessary measures to eliminate illiteracy will be undertaken. All necessary encouragements will be given for the development of science, technology, arts and literature".

The Education Program of the National Democratic Revolution

> "The curriculum developed and text books prepared at central and regional levels will be based on sound pedagogical and psychological principles...giving due gender issues. Training will be provided on agriculture, crafts,...for those with the appropriate age".

Transitional Government of Ethiopia, Education and Training Policy ,1994.

These are some of the educational policies of the different governments in Ethiopia since the beginning of the sixties. In almost all cases education has been seen as a major driving force in accelerating the process of economic growth in the country. In addition to setting targets and drafting various strategies a considerable amount of recurrent and capital budget has also been poured into the educational sector. On the average, between 1969/70 - and 1973/74 13.25%, between 1974/75 - 1990/91 11.7 %, and between 1991/92 - 1992/93 12.65% of the total government expenditure was allotted to the educational sector [MOE , Basic Education Statistics].

The central belief in all of the above efforts was and is the thinking that accumulation of knowledge via education is a major decisive factor in economic development. Educated persons are expected to perform certain jobs and functions with higher efficiency and to adopt new technologies in a shorter period of time than uneducated persons. This is mainly because relatively more educated persons can easily gather, process and interpret all available information so as to differentiate between promising and unpromising investment areas and to make decisions with relatively small errors. Hence, education is expected to accelerate economic growth through enhancing the productive capabilities of all producers by breaking the tight grip of custom, thinking way of doing things and inefficient 'word- to -mouth communication patterns'. In addition, by exposing producers to a more systematic and dynamic production system and by enhancing their ability to choose the optimal bundle of inputs and output mix, education improves the allocative and technical efficiency of producers.

In Ethiopia, if education plays any significant role to play, it has to be reflected in the agricultural sector where nearly half of the GDP is originated, more than 90 % of the export revenue is generated, and more than 80 % of the employment opportunity is created. In a situation where the growth of the agricultural sector is seen as an energizer and pre-requisite for over all development and in an environment where there is a movement to change the educational structure, curriculum, and finance, there is a crucial need to asses the impact of education on the agricultural sector.

The transition from a centrally planned economy to a market economy has brought many economic changes that have direct bearings on the agricultural sector. Since 1991 most of the task of determining the prices of agricultural inputs and outputs have been left to the market forces; many of the state farms have been privatized, and the financial markets have been liberalized. In addition, as a result of the devaluation and the liberalization of the foreign trade and the demobilization of 500,000-1.2 million soldiers the supply and demand of agricultural inputs like fertilizer, labour, etc. have been changed significantly.

Even without these changes the physical and demographic situations in which farmers have been operating are in a continuous disturbance which needs permanent adjustment. The decline of yield as a result of soil degradation problems and the rapid decline in arable land-man and pastoral land-cattle ratios [Assefa, 1994, p.67] and the continuous redistribution of land can be sighted as examples of disequilibrium which demands the reaction of agricultural households. Thus, education is expected to have a significant impact in such dynamic environments than in 'static' situations. The reason is that in new and dynamic situations the stationary technology which guarantees a relatively long time to adjust to the new conditions through the existing working practices adopted in learning by doing practices, will be inadequate or obsolete [Azhar,1991]. This study tests the impact of education on farmers' ability in adjusting to these new situations.

In a country like Ethiopia where the possibility of increasing agricultural output through expansion of arable land and increasing the supply of modern inputs and improving agricultural technology is a remote possibility, there is a great demand for an alternative solution 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 the existing farmers' resource endowments and farming technology.

1.3. OBJECTIVES OF THE STUDY

The main objectives of the study are to analyze the impact of farmers' education on the efficiency of Ethiopian smallholders and to show if there are possibilities to increase agricultural outputs not only through increasing investments on new inputs and technologies but through the expansion of education.

Specifically the study has the following objectives.

1. To empirically test the 'poor but efficient' hypothesis in the context of the Ethiopian peasant agriculture and consequently to asses the existence of profit efficiency differentials among the sampled farmers at the existing factor endowments and farming technologies;

2. To test empirically the impact of farmers' education on their allocative and technical efficiency;

3. To analyze the effect of education on farmers' decision to adopt new technologies and to empirically test the impact of education on adoption of modern inputs under modern and traditional environments.

CHAPTER TWO

EDUCATION IN ETHIOPIA: AN OVERVIEW

2.1. INTRODUCTION

A series of studies on economic development confirm that "one of the most important factors in economic development is human capital. It has become clear that "people can't be economically productive and generally useful to the societies in which they find themselves unless they attain education at some level" [Mekete, 1988,p.189]. Various studies conducted based on aggregate production function in USA also showed that "the growth of the US economy during the first half of the 20th century was attributable to increase in the stock of human capital" [World Development Report, 1982].

High rate of primary education enrollment is usually considered as the corner stone of economic development. The importance of primary education is two fold. First it produces people with a basic knowledge of reading, writing and numeracy and second, it serves as a spring for further education [World Bank, 1990, p.2] It is also argued that "no country had achieved significant growth until after 8 to 10 percent of the total population was enrolled in elementary education" [Peaslee, 1969, p.316]. This is mainly because high elementary enrolment is the major means to change traditional 'crust of customs' and backward working practices and attitudes.

In this chapter an attempt is made to see the historical development of formal education in Ethiopia and its present status.

2.2. HISTORICAL DEVELOPMENT OF EDUCATION IN ETHIOPIA AND ITS PRESENT STATUS

In a country like Ethiopia with 3000 years of history it is very difficult to date back the exact beginning of education. However, it is believed that the Ethiopian Orthodox Church was the first educating institution in Ethiopian history [Teshome, 1979, p.10]. Though there were also some koranic and missionary schools in the country, this education system has long history which can be compared with other ancient educational institutions such as the Egyptian Coopts and the Chinese traditional schools. The contribution of this educational system to the development of the Ethiopian economy, however, is controversial. For instance, Mesfin Kinfu argued that "Though Ethiopia has had her own alphabets for quite a long time in history, and though 'education' as spread about by church school is not a new phenomenon in the country yet the methods which were followed by this institution were not in line with the needs of economic development" [Mesfin, 1969, p.1]

It was only during Menelik II the Ethiopian government started to participate in the education sector. In 1906 Emperor Menelik II opened the first government school, Menelik II, in Addis Ababa which 'acted as a nucleus' for the establishment of schools in the whole country. The Ethiopian modern education system had also showed great progress in the time of Emperor Haile Selassie. The participation of the government in expanding schools was continued until the Italian invasion and around 1936, there were at least 21 schools owned by the government [Teshome, 1979]. The Italian expelled all previous missionaries and they built schools and changed the curriculum, medium of instructions, etc. After the restoration of the Ethiopian government in 1942, the education sector was rehabilitated. Schools which were closed by the Italians were reopened, many other new were constructed and around 1953 the Ministry of Education [MOE] was able to launch a ten year plan for the development of education in the country [MOE,1960, p.11].

The expansion of schools continued after the 1974 Revolution with primary emphasis on elementary education. The Campaign of National Development Work Through Cooperation (Zemecha) and the literacy campaign were very important measures taken by the government to tackle illiteracy in the country. Education was also given special emphasis by the Ten-Year-Perspective Plan [1983/84- 1994/95]. The education system was planned to be changed from 6-2-2 system to 8-2-2 with special emphasis on technical and vocational education [Teshome,1988, p.178]. It was also planned to offer universal education up to 8th grade and general and poly technical education for 9-10 grades and for 11-12 grade students respectively. However, most of the plan targets were not achieved due to various reasons coupled with the ambitious nature of the plan itself.

After the 1993/94 political change, the economic policy of the country changed from socialist oriented to market economy. Structural Adjustment Program (SAP) has been introduced in the country. In the education sector the number of schools constructed for all levels of education has increased, the teacher student ratio has decreased significantly and students are allowed to study primary education in their own language. The past and the present status of the country's education can be assessed by using indicators such as literacy and participation rates, educational expenditures, etc.

The literacy level before 1974 was less than 10 percent and this level dramatically increased between 1979 and 1989 and it reached 76 % in 1990 [MOE ,1993]. It was estimated that as a result of 20 national literacy campaign rounds carried out between 1979 and 1989, 21.3 million adults were registered and more than 90 % were passed the basic literacy test. Despite such impressive results in the reduction of illiteracy, much emphasis has not been given by the present government to further increase literacy or to maintain it through continuing education.

A considerable change has also been registered in the level of primary school enrolment in the past three decades. Primary school enrolment has increased from 859,000 to 2,466,000 between 1974 and 1990. The participation of females has also shown dramatic change over time. It increased from a mere 10 % in 1974 to 29 % around 1990. One can also see drastic changes in junior and secondary school enrollments, in the number of schools and teachers, in the amount of recurrent and capital expenditures, etc., between 1974 and 1994 [for the detail see MOE Basic Education Statistics, various issues]. Some of the basic indicators of the education system of the country in the past two decades are presented in Table 2.1.

Table 2.1. Some Basic Indicators of the Education System in Ethiopia.

Year	No. of Schools			Enrolment			Total education expenditure '000 Birr
	primary	junior	senior	primary '000	junior '000	secondary '000	
1973/74	2754	420	113	860	102	81	158285.1*
1979/80	5219	706	167	1811	186	185	253283.2
1984/85	7392	909	227	2408	320	282	391760.9
1989/90	8345	1092	274	2662	418	452	577199.0
1990/91	8256	1117	275	2466	405	454	598640.8
1991/92	8434	1149	284	2064	359	416	n.a
1992/93	8120	1099	279	1856	349	6364	n.a
1993/94	8674	1167	303	2284	357	357	1296875.0**

* for 1974/75 ** for 1994/95; n.a = Not available

Source :MOE, Basic Education Statistics, various issues.

2.3. MAJOR PROBLEMS IN THE ETHIOPIAN EDUCATION SECTOR

1. Low efficiency :

The Ethiopian education sector is bounded with many problems ranging from low efficiency to lack of indigenous and well organized curriculum. The efficiency level of an education system can be measured by the rate of retention and performance in national examinations and the like. High rates in the level of dropouts and repetitions are an indicator of low efficiency and high performance in national examinations indicate high efficiency.

Several indicators of the retention rate can be used to evaluate the internal efficiency of a given education system. Survival by grades and number of graduates from the final year of primary cycle are the most common indicators that can be used to evaluate efficiency in education. Based on the 1993/94 information the survival rate for grade 2 was 59.1 % for boys and 49.0 % for girls. This indicate that 51 % of girls and 40 % of boys dropped out from the system before entering grade 2 [Education Statistics, 1996, p.106]. According to MOA, in Ethiopia the efficiency loss associated with dropouts is higher than the loss related to repetition. It is argued that "74.6 % of total wastage is due to dropouts (boys 78 % and girls 78 %). Wastage due to repetition is 23.6 % (boys 25.2 % and girls 22.0 %)" [Education Statistics, 1996, p.108].

The evaluation of the system by the number of students who passed national examinations also showed high level of inefficiency. Out of 1.8 million students sat for grade 8 National Examinations only 61.1 % passed the exam in 1993/94 [Education Statistics, 1996]. The result of the Ethiopian School Leaving Certificate Examination [ESLCE] was also deteriorating. In 1990/91 out of 100,000 students who sat for ESLCE, 94 % did not get enough grades which enable them to join higher institutions in the country. The over all efficiency of the education system can thus be evaluated with the help of the above indicators.

In 1993/94, according to MOE, the over all efficiency of the elementary education system was found to be around 60 %. This implies that much has to be done to reduce the 40 % inefficiency in primary education.

2. Inadequate payment to teachers:

It is argued that the salary of teachers was determined by Central Personnel Authority long time ago and it was kept constant irrespective of the dramatic increase in the cost of living. Though this was the case for all government servants, salary promotion was almost unknown in MOE for teachers. This reduces not only the motivation of teachers to teach and to stay long in the education system but also the possibility of other new graduates to join the teaching profession.

3. Inadequate facilities:

In MOE, shortage is a commonly reported problem. There is shortage of class rooms, teachers, laboratory equipments, books, etc. All these shortage problems have greater impact on efficiency of the education system. For instance due to shortage of class rooms two shift system was introduced and in some cities three shifts were introduced. The number of students in one class is also almost twice of the recommended level. Shortage of laboratories and chemicals in most of the Ethiopian high schools also compelled students to spend much of their time on theoretical issues rather than on practice.

4. Lack of well designed curriculum:

The other serious problem in the Ethiopian educational system is lack of well defined and indigenous curriculum. It is argued that the Ethiopian curriculum was a replica of Grate Britain and United States before 1974 and a direct copy of East Germany after 1974 [Ruh, 1992, p.23]. This lack of endogenity has brought problems such as incapability of relating theories with realities of the country, problem of teaching students practical skills which can be implemented in their day to day life, etc. This means that despite the relatively high progress achieved in increasing enrolment rates, the bookish education system has been producing functionally illiterate persons with no tangible skills required by the country. Therefore, a great emphasis has to be given in redirecting the content and skill mixes of education and in deciding the best balance between levels of education towards the actual need of the country. As it is pointed out by one researcher :

> " while primary education will have the end result of diffusing literacy, it should be designed primarily to improve the general intellect of the mass of the population, widening their horizons,and making them more susceptible to the inculcation of ideas for more progress and more productive systems and method of agricultural organization, cultivation and the development of agro-based and allied industries. The curriculum, text-books and practical experiences of schools should predominantly reflect the rural back ground and its potential [Yesufu, 1974,p.36].

Mesfin Kenfu also concluded that

> "... if education is to contribute effectively to Ethiopian economic development then the high wastage of students in the school system must be reduced, the educational system should stress the technical and vocational training and the existing high level human resources should be efficiently utilized "[Mesfin, 1968,p.9]

5. Unequal distribution of educational opportunities:

The unbalanced distribution of educational opportunities between urban and rural areas is also another serious problem. In the country there was no clear policy regarding the distribution of educational institutions.

> "Up until the eve of the Ethiopian Revolution of 1974, the 1943 order and its two ammendements of 1966 constituted the legal foundations of the Ethiopian education system. These defined the duties and responsibilities of the MOE, but made no reference to the distributional issues of educational services.

...The Proclamations relating to education and issued by the Ethiopian government since 1974 make no direct reference to a regional educational policy. ...The Ten Year Perspective Plan itself has not developed a regional policy for education" [Teshome, 1988 , p.177]

Table 2.2. Percentage of Urban Enrolment Rates and Schools

Region	Primary		Junior		Senior	
	schools	enrollments	schools	enrollments	schools	enrollments
Addis Ababa	100.0	100.0	100.0	100.0	100.0	100.0
Afar	17.6	50.8	66.7	81.7	100.0	100.0
Amhara	11.3	39.3	57.2	84.9	86.8	94.8
Bens.-Gumez	8.2	21.7	78.6	97.0	100.0	100.0
Dire Dawa	69.2	94.7	100.0	100.0	100.0	100.0
Gambela	22.4	23.5	20.0	14.7	25.0	11.2
Harari	63.6	90.8	100.0	100.0	100.0	100.0
Oromiya	12.0	33.8	56.4	79.7	96.3	97.8
SNNP	8.2	17.7	36.3	59.5	82.5	95.7
Somalia	19.4	37.1	100.0	100.0	100.0	100.0
Tigray	18.2	39.5	78.3	91.9	85.7	95.9

Source : Education Statistics , Annual Abstract , 1994/95

As a result of these and other reasons the rural-urban distribution of schools and educational facilities in the country is very skewed. Consequently there was a significant difference in enrolment rates between rural and urban areas. For instance in 1973/74 the two towns (Addis Ababa and Asmara) constituted over 25 percent of the primary school enrollments. Interms of budget share the inequality was much worse. For instance in 1970/71 Addis Ababa with a population of less than 4 percent of the total population received over 20 percent of the total budget of the MOE [Fasil, 1990, p.61].

Despite various measures taken since 1974 the distribution of schools and enrolment rates are still higher in urban areas than in rural areas. Table 2.2 shows the share of urban centers in schools and enrolment rates in the country. The table clearly shows how rural areas are neglected with regard to the distribution of schools and how enrolment rates are very low in these areas at all levels. Concerning this Mekete wrote

> " The rural areas are neglected with regard to the distribution of the existing educational services. We have the grievous situation of inaccessibility of the education to the largest section of the population. Reginalization of education must aim at basic general education for the rural population to a level that can serve as a basis for further leaving through formal and formal education" [Mekete, 1988, p.189].

CHAPTER THREE

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 precluding 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 of per capita income was attributable to the stock of productive skills and knowledge accumulated through education.

The importance of education in contributing to the growth of national income was first recognized around 1960's after researchers showed that the conventional factors of production like the growth of the stock of capital and the growth of the labour force failed to explain a considerable amount of the growth in national income. Education which can be used as an approximation to the growth of human capital was suggested to explain this unexplained residual [Appleton & Mackinnon, 1993]. Recent empirical studies tried to estimate the contribution of education to economic growth and they found the highest rate in Africa. Even though the quality of the data used is not so much reliable, intercontinental comparisons show that the contribution of education to economic growth is 17.2 % in Africa; 11.1 % in Asia; 8.6 % in Latin America; and 5.1 % in N.America and Europe [Pasacharopoulos, 1984].

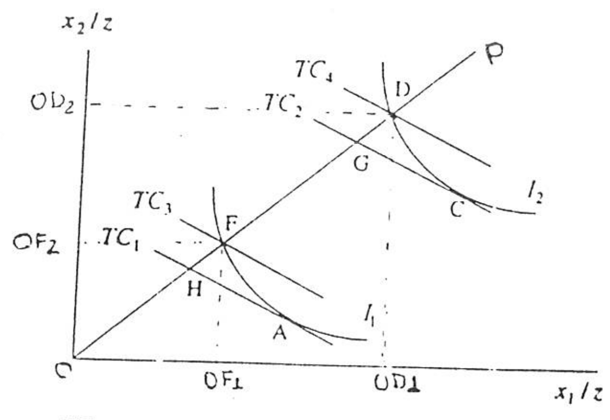
Aside from its contribution to macro economic development it is also hypothesized that education affects agricultural productivity by improving both the allocative and technical efficiency of farmers. Thus, before reviewing various works done to measure the contribution of education in increasing efficiency or in reducing inefficiencies in agriculture, it seems reasonable to define technical and allocative efficiencies, to analyze various measurement methods and to see the theoretical issues underpinning them.

3.2. ALLOCATIVE AND TECHNICAL EFFICIENCY

3.2.1. Definition

Allocative efficiency [AE] can be defined as the ability of a farm to maximize profit by equating marginal revenue product of inputs to their respective marginal costs. It arises from a choice of better utilization of the existing inputs. Technical efficiency [TE] is also 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 is intensively discussed in the literature and it can be easily and clearly presented using the following diagram following the work of Farrell(1957).

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



TC = total variable cost; I = unit isoquant

Source : Sadoulte and Janvry, 1995, p. 243

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 inputs to its market prices. Point A which is the intersection point of the isoquant curve I_1 (which shows the most efficient input utilization curve per unit of output) and the total variable cost curve TC1 (which represents the minimum cost level) depicts the most efficient production point.

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. If we draw a straight line from the origin to point P, all points along this ray will represent equal factor proportions [Seitz,1990]. However, 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. In other words, the relatively efficient farm (point F) uses only OF_1 units of x_1 and OF_2 units of x_2 compared with the farm at point D which uses OD_1 & OD_2 amounts of x_1 and x_2 respectively. 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].

In a dynamic environment with imperfect information and multi-product farm allocative, effect has two aspects: allocation of resources among competing products based on changing input and/or output prices and allocation of factors of production based on their quality, quantity, and price [Patric & Kehtbetg, 1973]. Allocative ability involves the reallocation of resources after a decision maker perceives, collects, analyzes and acts decisively in response to various changes in economic conditions [Huffman, 1977]. That is why it is generally regarded as an acquired skill.

Based on fig. 1. we can clearly see the AE aspect of economic efficiency either without assuming TE or by presupposing TE. Allocative inefficiency arises from the failure of farms 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 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. Based on Farrell's approach, Sadoulet and Janvry summarized the technical and allocative efficiency of point D as follows:

1.TE $= TC_3/TC_4 = OF/OD$

2.AE

a) Based on current technology $(AE_1) = TC_2/TC_4 = OG/OD$

b) If TE is presupposed $(AE_2) = TC_1/TC_3 = OH/OF$

3. Overall efficiency (Economic efficiency)

$$= TC_1/TC_4 = (TE)(AE_2)$$

3.2.2. The Relative Importance of AE and TE

The most interesting and controversial issue in the literature is the relative importance of TE & AE in production, especially in small agricultural households. The controversy ranges from measurement problems and underlying assumptions to relative importance in terms of magnitude.

It is argued that AE which presupposes profit maximization and perfect input and output markets, is not applicable for subsistence farmers who are operating at various risks and in imperfect and costly information environment. It is also argued that in developing countries farmers do not strive to maximize profit and the market conditions are full of imperfections [Assefa, 1995, p. 65]. Ekayanake also mentioned three main difficulties in estimating AE in peasant agriculture. First if farmers don't maximize profit due to risk aversion behaviour, their optimal input demand levels may differ from those farmers who are risk neutral or risk averse. Second, " even if they maximise expected profits they would appear to be alloatively inefficient 'ex-post' if their prior expectations deviated from the realised outputs and input prices". And finally, in the subsistence agriculture where input markets are less developed, market may not be a good indicator of the opportunity cost of inputs, such as family labour. As a result he estimated what he called 'apparent allocative efficiency'. It is also argued that the main a priori assumption in computing AE and even TE is the expectation that "computation will force less efficient farms to become more efficient or go out of business" [Shapiro, 1980, p.181]. However, Shapiro pointed out that in rural areas the reverse is true. A farmer usually helps her/his neighbours in the case of production crisis rather than forcing them to be out of business. The rationality and the maximization of satisfaction assumptions of efficiency are also criticized by Shapiro based on the ground that the assumptions are valid only if farmers have non-diminishing marginal utility of money. However, this may not be the case in rural areas where social obligations, leisure, status, etc., are also very important [Shapiro, 1980]. In addition to these, estimation of farmers' efficiency in terms of AE is criticised on its relative small share from the total economic efficiency and on its inapplicability in cross-sectional studies where the input and output variations across farms are insignificant [Shultz, 1964, p.37; Leibenstein, 1966; Azar, 1991; Assefa, 1995:]. For instance, after reviewing such and other related studies Assefa concluded that :

> "The controversies surrounding the theory, application and interpretation of price efficiency (AE) are numerous. In general one may conclude that measuring AE is both conceptually and operationally difficult. On the other hand it is possible and valid to estimate producers' performance in terms of TE or production efficiency since this would avoid many of the criticisms on the price efficiency concept and there are no acceptable justifications for technical inefficiencies. The measure of TE relies less on the assumption of perfect knowledge, perfect competitive markets and profit maximization hypothesis." [Assefa, 1995, p. 66-67].

However, in spite of the above criticisms and problems, many researchers have tried to measure AE of small farmers from a cross sectional data mainly due to various reasons presented in section 4.2.1. of this study.

3.3. MEASUREMENT

The next issue in analyzing the effect of education on farmers' efficiency is the measurement problem. In this section an attempt is made to review the methodologies of different studies which are related to this study.

3.3.1. The Adjustment Model

Huffman (1977) used the adjustment model in the U.S. agriculture to measure the impact of human capital on allocative ability. He pointed out that the price of nitrogen fertilizer declined by 22-25 percent between 1959 & 1964 and during the same period the nitrogen responsiveness of new hybrid-corn varieties were increased significantly. In addition to these the consumption of fertilizer in the corn belt of 5 states of the U.S. increased almost twice. These disequilibria created in the economy, according to Huffman, could be used to determine the contribution of education and other related variables on the adjustment ability of farmers. He used the model

$N_t^* = D(P_t^*, T)$ ... The demand function

$N_t - N_{t\,5} = \beta(N_t^* - N_{t-S})$ ... The adjustment or reaction function.

$\beta = \beta(E),\ 0 < \beta < E$

where

N_t^* = the optimal quantity of fertilizer/acre/ year

P_t^* = permanent real factor prices

T = A Vector of environmental variables

N_t = the actual quantity of fertilizer used/ acre/year

β = the adjustment coefficient

Z = a vector of socio-economic variables.

A unitary value of β implies complete adjustment within 5 years time and a zero value indicates no adjustment at all during the 5 years period. About the importance of this model Huffman wrote:

> "The model is unique in that the adjustment coefficient β is specified as a function of a vector economic variables Z. The variable coefficient specification permits a test of the hypothesis that economic variables explain differences in the rate of adjustment, a measure of allocative performance, to the permanent components of changes in economic incentives, example, to disequilibrium" [Huffman, 1977, p.86].

He used a logistic type of function to specify the adjustment coefficient and he concluded that "decision makers with more education can more quickly grasp changes and adjust more quickly and accurately to them" [Huffman, 1977, p.96].

3.3.2 Engineering Approach

An engineering production function can be used to investigate the effect of education on efficiency. Let the production function be as follows.

Q = f(X,E)..................(1)

where **Q** is physical output

X represents various inputs and

E is education (both formal and informal)

Based on this presentation $\partial Q/\partial E$ gives the marginal product of education. A Cobb-Douglas production function is usually used in literature to specify the engineering production function like this:

$$Qi=\alpha\prod_{j=1}^{n} Xji^{\gamma i}...j=1,...,n...(2)$$

where

Q_i = output of the ith farm

X_{ij} = the j^{th} input of the i^{th} farm

α = an efficiency parameter and γ is parameter to be estimated.

However, a problem arises as to how to incorporate the education variable (formal schooling; work experience such as age, extension contact; etc.) in the specification like (2). Some of the approaches to solve this problems includes:

1. The education variable can be zero for some farm households and this limits the estimation of (2) using log linear transformations. Dropping observations with zero educational value or substituting very small number for zero values will significantly reduce the degrees of freedom and or more importantly will reduce the unbiasedness of the estimates [Azhar, 1991]. The easiest solution for this problem is to specify education as a shift variable or to take log[ED+1] where ED is number of years of education.

2. The next problem, is how should the education variable be incorporated in equation (2). There are two different major ways suggested by Moock (1981): to incorporate it in neutral fashion i.e., without changing the elasticity of other inputs (Xj) and in non-neutral way. If education is assumed to alter the elasticity of other major inputs equation (2) can be written as

$$Qi=\alpha\prod_{j=1}^{n} Xji^{\gamma j}E^{B}e^{Ui}\ldots\ldots(3)$$

However, if different farmers are assumed to have different elasticities of inputs based on their levels of education, equation (2) will take a form of

$$Qi=\alpha\prod_{j=1}^{n} Xji^{(\gamma j+\beta jEi)}e^{Ui}\ldots\ldots(4)\ [Mook,1987]$$

Lockneed, et.al., specifies the following different production functions of Cobb-Douglas types to show how elasticities and marginal product of education can be calculated based on various studies they reviewed.

$$Q=\alpha_o\prod_{i=1}^{n} X_i^{\alpha i}E_i^{\beta i}e^{\sigma EXT}\ldots\ldots(5)$$

$$Q=\alpha_o\prod_{i=1}^{n} X_i^{\alpha i}e^{(\beta i E_i+\sigma EXT)}\ldots\ldots(6)$$

$$Q=\alpha_o\prod_{i=1}^{n} X_i^{\alpha i}e^{(\beta i E_i+\sigma EXT)}\ldots\ldots(7)$$

$$Q=\alpha_o\sum_{i=1}^{n} \alpha_i X_i+\beta_i E_i\ldots\ldots(8)$$

where

Q	= gross output in physical units
X_i	= n essential inputs such as land, labour, capital, etc.
E	= Years of Schooling
EXT	= A dummy variable which shows exposure of the farmer to extension
D	= 1 if E is greater than any specified level and 0 otherwise.

In equations 5, 6, and 7, β gives the elasticity of output with respect to years of education, the percentage increase in output as a result of a one unit change in education, and the percentage change in output with the educational level D compared with the reference case respectively. In the last linear specification, β gives the marginal increase in output as a result of a one unit change in education. Similarly σ gives a measure of the productivity of agricultural extension [Lockneed, et.al., 1980]. Lockneed, et.al., also showed some of the advantages of the engineering production function approach over the methods that uses wage rates as a proxy for marginal productivity so as to assess the impact of education on the wage level.

1) no assumptions need to be made about equivalence of wages and the marginal product of labour;

2) the possibility of screening doesn't confound an interpretation of the results; and

3) only in this way is it possible to obtain estimates of the effect of education on productivity in sectors, such as agriculture, that may rely relatively little on wage employment [Lockneed, et.al., 1980].

Various researchers have used one or more of the above models to estimate the contribution of education to agricultural productivity [for a good survey see Lockneed, et.al., 1980 and Phillips, 1994] and they found a positive and significant worker 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 'worker effect' only, since it considers inputs as to be given [Welch, 1971]. In other words $\partial Q/\partial E$ shows only the worker effect and it doesn't 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 Forsund et al., 1980]. A further limitation of the engineering production function is that if we do not assume farmers are maximizing expected profits, the estimation of the equation by OLS yields biased and inconsistent estimates of the coefficients due to simultaneous equation bias. This is mainly because " under the production function approach some, or all of the independent variables 'may be' functions of the disturbance term" in equation like 2 above [Saleem, 1988]. Mubarik and Flinn also argued that

> "...a production function approach may not be appropriate when estimating the economic efficiency of individual farms because they may face different prices and have diffident factor endowments. As a result, they have different best-practice production functions and,thus different optimal operating points [Mubarik & Flinn, 1989, p.304].

Therefore another better model is required so as to capture both the allocative and worker effects of education.

Pudasaini tried to capture the allocative efficiency role of education in sugarcane production in Nepal from an engineering production functions like (1) by using two step procedures. In the first stage he estimated a production function like (1) and he derived the marginal value product of each variable inputs. Then, he calculated

$$\acute{E} = | MVP_{ji} - P_{ji} |$$

where

$\acute{E}$ = the allocative error

MVP_{ji} = the marginal value product of input j of household i;

p_{ji} = the price of input j for household i

In the second stage he regressed

$$\ln \acute{E}^2 = \beta_o + \sum \beta_i X_i + U_i$$

where X_i = various socio-economic variables including education to know whether education has any effect on the allocation of sugarcane production or not [Pudasaini, 1983].

3.3.3 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 $\mathbf{X} = (x_1, x_2, \ldots, x_n)$, and **m** fixed inputs $\mathbf{Z} = (z_1, z_2, \ldots, z_n)$ and a vector of expected prices for variable inputs $\mathbf{W} = (w_1, w_2, \ldots, w_n)$ the maximum attainable output is given by $\mathbf{f(X,Z)}$, and then the maximum restricted profit (total revenue less variable cost only) will be $\mathbf{\Pi(P,W,Z)} = \max_{Y,X}\{py - W'X / f(X,Z) \geq Y\ ,\ X \geq 0,\ Y \geq 0\}$ where $\mathbf{\Pi}$ is the price of the output Y [Førsund et al, 1980]. Profit maximizing 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 normalized profit and normalized 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 [for instance see, Lau & Yotopoulos, 1971; Pudasaini, 1983; Ali & Flinn, 1989; Sadoulet & Janvry, 1995]. The above authors mentioned the following principal advantages of the profit function approach vis-a-vis the engineering approach for analyzing the contribution of education to efficiency in agriculture.

1. The profit function and the input demand functions are expressed in terms of exogenous variables, i.e., in terms of price of inputs and outputs. Thus the possibility of simultaneous equation bias will be reduced when these functions are estimated.

2. Both the allocative and technical efficiency effect of education and the relative efficiency of educated and illiterate farmers can be estimated without deriving the allocative error function shown above.

3. As indicated by Zellner, by using seemingly unrelated regression method efficient estimates can be derived from the profit and input demand functions.

4. 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 consequentially the optimal operating point is different for different farmers.

As a final comment we can take the conclusion given by Kalirajan as to why and how the profit function is superior to the production function.

> "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 maximization 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, pp. 308-309].

However, it is not always feasible to derive the profit function as shown above and it is customary to take the profit function as given as long as the function is "non negative, monotonically increasing in output prices and decreasing in input prices, convex, homogenous of degree zero in all prices, displays constant returns to scale & homogenous of degree one in all fixed factors" [Sadoulet & Janvry, 1995, P.63 see also Varian, 1992, p.41; Gravelle and Rees, 1992, p.86].

Based on the work of Yotopoulos and Lau [Y-L] (1973) many authors [Levy, 1981; Pudasaini, 1983; Saleem, 1988; 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 maximizing input demand equations of the form

$$\ln\Pi=\ln\alpha_0+\delta^1 D^1+\beta_i \ln W_i+\gamma_i \ln Z_j+U_i \ldots (1)$$

$$\frac{-W_i X_i}{\Pi}=\beta_i D^1+\beta_i D^2+V_i,\ i=1,2,\ldots,n.\ldots(2)$$

where

π_i	=	restricted profit
W_i	=	variable input prices
Z_i	=	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

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 always due to factors under their control perse, but also owing to exogenous shocks which are out of their control [Kumbhakar, 1988; Maddala, 1992, p.387-388]. In (1) and (2) above U and V represents statistical errors and other exogenous factors which are out of the control of the decision makers such as weather, 'divergence between expected and realized prices', etc.

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

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 the same as comparing the parameters of the profit functions of the two

groups. This is also "equivalent to testing whether the coefficient of the dummy variable differentiating the two profit functions (i.e,. σ) is zero" [Kalirajan, 1992,p.308].
Thus

H0 : $\sigma^1 = \ln (\alpha_o^1/\alpha_o^2) = 0$

where α_o^1 and α_o^2 are constants of the profit function of group 1 and 2 if separate functions were estimated for each group. 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 separately test these efficiency differentials of the two groups.

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, p.308]. Therefore the null hypothesis will be

Ho : $\beta_i^1 = \beta_i^2$

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

Ho: $\sigma^1 = 0$ **and** $\beta_i^1 = \beta_i^2$

iv. **Absolute allocative efficiency:** The absolute allocative efficiency of the two groups can be also tested by the hypotheses:

Ho : $\beta_i = \beta_i^1$

Ho : $\beta_i = \beta_i^2$

Based on this approach Pudasani (for Nepal, 1983), Saleem (for Sudan, 1988), and Kalirajan (for India, 1993) investigated the allocative, technical and overall economic differentials between literate and illiterate farmers, farmers under Joint Account and under Land-Water-Change system, and between small and large farmers growing high yielding varieties respectively. If we select the work of Pudasani, which out of many studies in this area, has a direct relationship with ours, we get the following conclusions.

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 characterized by changing technology, and
b) The profit function approach captures the allocative effect of education more clearly than the production function model [Pudasaini, 1983].

A related method to the above approach is a model used by Levy in his estimation of the efficiency differentials between the public and private sectors in Iraq. Instead of the profit and the input demand functions, Levy uses the input demand and the output supply functions for estimation since the profit function has a complicated nonlinear error-term structure [See Levy, 1981 for the detail]. Then he estimated the following two equations:

$$\log X^d = \theta p D_p + \theta g D_g + \lambda ptp + \lambda g^* tg - \alpha \log W + \beta^* \log Z + e_1$$

$$\log Y^s = \delta p D_p + \delta g D_g + \lambda p^* tp + \lambda g^* tg - \alpha \log W + \beta^* \log Z + e_2$$

where $e_1 = \alpha E$ and $e_2 = \alpha^* E + U$

D_p = 1 for private firms and 0 otherwise

D_g = 1 for government firms and 0 otherwise

X^d = firms supply function

X^s = firms factor demand function

λi = the rate of technological change , t = time, Θ_i and δi (i=p,y) are the intercept of the labour demand and output supply functions respectively. By using the full-information maximum likelihood estimation package he estimated the above two equations and tested the hypotheses that are similar to what we have stated earlier. The principal advantage of this method is its ability to disintegrate the deviations from the optimal value into systematic mistakes and random mistakes made in allocating inputs [E] and outputs [U] [Levy, 1981].

Craig c.Wu also used a relatively different method to measure the allocative, technical and scale effect of education. Starting from production function

$$Y^a = f(Z^o, X^o, E)$$

where Y^a is anticipated output, Z^o is a vector of observed fixed inputs, X^o is a vector of observed variable inputs and E is educational attainment of the farm operator, he derived the profit maximizing amount of variable input j as $X^*_j = g^*_j(Z^o, E)$ and consequently the optimum output as $Y^* = f(Z^o, X^*, E)$. Then he denoted the maximum profit function by $\pi^* = Y^* - C^*$ where C^* is the optimum variable costs. Then after some manipulation he derived the following equation by which the contribution of education to the three forms of efficiency can be calculated.

$$\frac{d\pi^a}{dE} = \pi^* \frac{d\mu}{dE} + \mu \frac{\partial f^*}{\partial E} + \mu \sum \{ (\frac{\partial f^*}{\partial X^*_j} - 1) \frac{\partial g^*_j}{\partial E} \}$$

Where $\mu = \pi^a / \pi^*$, $\pi = Y^a - \Pi Xi^o = Y^a - C^o$

Then $\pi^*[d\mu/dE]$, $[\mu\partial f^*/\partial E$, and $\mu \sum \{([\partial f^*/\partial X^*j]-1)[\partial g^*j/\partial E]\}$ measure the allocative, technical, and the scale effect of education respectively [Wu, 1977]. Though this method seems a good approach to measure the impact of education on efficiency, including non-conventional inputs in the production function is not supported by many researchers as discussed in section 4.2.2 of this study.

The great convenience of the profit function model is not, however, without limitations. As argued by Aigner, Lovel, and Schmidet such functions do not allow as to estimate farm specific efficiency levels [Aigner, Lovell, and Schmidt, 1977]. This demands the estimation of frontier models which are believed to over come the limitations of the Y-L type of profit models.

3.3.4 Frontier Models

The main interest in the use of various frontier models is the measurement of inefficiency. The concept, types, historical development , associated assumptions, and limitations of various forms of frontier production functions are intensively discussed in literature (for instance see Førsund, et.al., 1980; Assefa, 1995). In our case we will see some of the works which out of many studies in this area, have direct relations with this study.

The importance of stochastic frontier against the Y-L and the deterministic frontier models is emphasized in recent studies. For instance, some of the conclusions given by different researchers include:

> "The more recent development of profit function models has allowed the testing of differences in average allocative and average technical efficiency between groups of producers. However, these models do not provide a numerical measure of firm-specific efficiency"[Ali and Flinn, 1989, p.304].

> "The advantage of stochastic production with two error terms approach over the deterministic and probabilistic approaches is that firm-specific efficiency and random- error effect can be isolated"[Ali and Claudhry, 1990, p.64].

> "The deterministic frontier imposes the limiting assumption that any deviation from the frontier is the result of inefficiency....To avoid this problem, we estimate a stochastic production frontier model"[Bravo-Ureta & Rieger, 1991, p.423].

The word frontier indicates the maximum limit of a production or profit 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, p.5].

Theoretically the production, profit and cost frontier functions can be derived given input and output prices data in addition to the conventional data requirements. As shown in section 3.3.3, the functions which shows the maximum attainable output level **f(X,Z)**, the maximum profit level **Π(P,W,Z)**, and function which shows the minimum cost requirement **C(Y,W)** can be taken as frontier functions since they show the maximum (in the case of **f(X,Z)** and **Π(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 $f(X^1,Z^1)$ 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 $(PY^1-W'X^1/Z^1) \leq \Pi(P,W,Z^1)$ [Førsund et al.,1980]. The allocative efficiency of this particular farm can also be analyzed 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 minimized and consequently the profit level will not be the maximum possible. Thus $W'X^1 > C(Y^1,W,Z^1)$ and $(PY^1-W'X^1) < \Pi(P,W,Z^1)$.

Førsund et al.,[1980] indicated that "Observed expenditure $W'X^1$ coincides with minimum cost $\mathbf{C(Y^1,W,Z^1)}$ if, and only if, the firm is both technically and allocatively efficient". They also showed that the fulfillment of allocative and technical efficiency will not guarantee maximum profit as the farmer can be scale inefficient. A firm is said to be scale efficient if $\mathbf{P} = \mathbf{Cy(Y^1,W)}$.... It follows that $\mathbf{(PY^1 - W'X^1) = \Pi(P,W)}$ if, and only if, the firm is technically, allocatively,and scale efficient [Førsund et al.,1980].

The next issue is the translation of this theoretical presentation of the frontier functions into concrete estimation procedure. Consider a hypothetical frontier production model given by Kalirajan and Shand [1989].

$$Y_{it} = \beta_o \Pi (X_{ijt})^{\beta j} \quad ....(3)$$

where Y_{it} = the maximum possible output of the i^{th} farm (i=1,2 ,...,n) in period t (t=1,2,...,T)

X_{ijt} = the j^{th} input used by the i^{th} farm in period t

β_j = the coefficient to be estimated (j=1,2,...,m)

Equation (3) gives the maximum output without any technical inefficiency . If,however, the i^{th} farm do not produce on the frontier line owing to various reasons equation (3) will take a form

$$\mathbf{Y_{it} = \beta_o \Pi (X_{ijt})^{\beta j} e^{\epsilon it} \quad ....(4)}$$

Now in equation (4) 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. However, the actual production level will deviate from the frontier due to 'acts of nature' or factors out of the reach of the decision maker and/or due to 'human errors'. Aigner, Lovell, and Schmidt and Meeusan and Broeck succeeded in decomposing ϵ_{it} in to such two parts [Aigner et al., 1977].

Kalirajan and Shand wrote that " ... in the production process the output Y is determined not only by the technical efficiency of the firm, but also by exogenous shocks not under the control of any firm, such as weather variation" [Kalirajan and Shand,1989, p.76].

Let $\epsilon_{it} = \mathbf{U}_{it} + \mathbf{V}_{it}$ .....(5)

In (5) 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 from the best practice and consequently measures 'technical efficiency relative to the stochastic frontier' $\mathbf{Yit} = \beta_o \Pi(X_{ijt})\beta_j e^{Vit}$ [Dauson et al.,1991]. Dawson et al. clearly stated that in equation (5) above

> "the symmetric component,Vit, permits random variation in output resulting from factors outside the control of the farm like weather, disease, and so on. The one-sided component, $U_{it} \leq 0$, reflects technical efficiency relative to the stochastic frontier,(3) " [Dawson et al., 1991, p.1099].

Then equation (4) will be written as

$$\mathbf{Y}_{it} = \beta_o\, \Pi(\mathbf{X}_{ijt})^{\beta j}\mathbf{e}^{(Uit+Vit)} \quad ......(6)$$

To estimate β_o, β_i, U_{it}, and V_{it} of equation (6) we have to make certain assumptions about the error terms U_{it} and V_{it}. Following Aigner et al., and Meeusen and Broeck, the following assumptions are made.

1. $V \sim N(0,\sigma_v^2)$ and not correlated with U
2. $U \leq 0$, and $U \sim N(0,\sigma_u^2)$

Now equation (6) can be estimated by maximum likelihood methods [Dawson,at al.,1991]. If U_{it} is not included in (6), equation(6) will be reduced to equation (1) of section 3.3.3 which is average frontier' 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].

Then

$$e^{Uit}=\frac{Y_{it}}{\prod (X_{ijt})^{\beta j}eV_{it}}=\frac{Y_{it}/Uit}{Y^{*}_{it}/Uit=0}=\frac{actualoutput}{potentialoutput}\ldots(7)$$

which is the ratio of observed output to the maximum achievable stochastic level given that technical efficiency is fully realized [Dawson et al., 1991]. Taking logarithm of both sides(by assuming constant technical efficiency through time i.e. $U_{i1}=U_{i2}=\ldots=U_{iT}=U_i$) gives

$$\mathbf{U_i = \ln Y_{it} - (\sum \beta_j \ln X_{ijt} + V_{it})}.$$

The derivation of farm specific estimates of efficiency was first demonstrated by Jondrow et al., [Ali and Flinn, 1987] by assuming a different distribution for U_{it} and V_{it}. They assumed a half-normal distribution for U_{it} and full normal distribution for V_{it}. Kalirajan and Shand argued that the validity of these assumptions can be tested either by using 'a family of convolutions' or by 'plotting' ($U_{it} + V_{it}$) for each individual farm and output levels [Kalirajan and Sand, 1989, p. 1138].

Once the assumptions are made firm specific technical efficiency "is obtained by calculating the mean of the conditional distribution of the inefficiency error(Ui) given the total error ($U_i + V_i$)" [Hill and Kalirajan, 1993] as

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

where $\gamma = \sigma_u^2/\sigma$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\phi(.)$ and $\Phi(.)$ are standard normal density and cumulative distribution functions evaluated at $[(U+V)/\sigma][(\gamma/(1-\gamma))^{1/2}]$ respectively. For the detail of the derivation see Jondrow et al., 1982; Kalirajan and Shand, 1989; Dawson et al.,1991. Based on this basic principle various researchers tried to measure not only TE which is given by e^{Uit} but also AE of agents. For instance Sadoulet and Janvry showed that by using the following translog production frontiers

$$\ln q = \alpha + \Sigma_{i=1}^{m} \beta i \ln X_i + \frac{1}{2} \Sigma_{i=1}^{m} \Sigma_{j=1}^{m} \gamma_{ij} \ln X_i \ln x_j + U + V$$

$$c_i = \beta_i + \sum_{j=1}^{m} \gamma_{ij} \ln X_{ij} + w_{ij},\ i=1,2,..m$$

where c_i is the share of factor i in total revenue calculated as $p_i x_i / pq$ and by estimating them simultaneously by the above methods it is possible to get firm specific TE (U_i) and the" AE of each firm i with respect to each input j can be measured by the estimated residuals W_{ij}" [Sadoulet and Janvry, 1995, p.247].

Another attempt to estimate AE from the production frontier is the study made by Ekayanake[1987]. He tried to measure farm specific AE of farmers in Sir Lanka by deriving farm specific production functions (Q_i) from the estimated frontier function (Q_f). In his words

> "If farmers maximize expected profits, a measure of their AE can be obtained by comparing the maximum profit for a given farmer with the predicted profit at the level of inputs actually used....Farmer-specific production functions(Q_i) can be obtained by a neutral transformation of the estimated production frontier by the level of TE of the farmer" [Ekayanake, 1987, P.511].

By assuming a Cobb-Douglas production function he derived Q_i as

$$Q_i = A \prod X_i^{\beta i} \prod Z_j^{\gamma i} e^{Ui}$$

where

X_i and Z_j are variable and fixed inputs respectively

A, β_i and γ are estimated coefficients of the frontier,

U_i is farm specific technical efficiency level derived by the method we have seen earlier.

By assuming farmers maximize profits given prices of outputs(p_q) and prices of inputs(W_i) and fixed factors of production, he used the first order condition as a test for AE as follows:

$$W_i = \frac{p_q \beta_i Q_i}{X_i} (K_i)$$

According to Ekayanake, K_i, measures "deviations from the allocatively efficient input levels" [Ekayanake,1987, P.512].

Another interesting attempt to measure both TE and AE was made by Bravo-Ureta and Rieger [1991] using the neo-classical duality of the stochastic frontier. They argued that "By extending Kopp and Diewert's decompsition technique from a deterministic to a stochastic model economic and allocative efficiency measures that are free from distortions, steaming from statistical noise, inherent in deterministic models can be estimated"[Bravo-Ureta and Rieger,1991 P., 423]. The basic method they followed can be presented as follows. First they estimated a stochastic Cobb-Douglas production function and by using the neo classical duality they derived the cost function analytically from the estimated coefficients. Then by using Shepard's lemma, they derived the 'system of minimum cost input demand equations'. After that they computed

TE $=$ $[X_t\text{'}p]/[X_a\text{'}p]$

EE $=$ $[X_e\text{'}p]/[X_a\text{'}p]$

AE $=$ $[EE]/[TE] = [X_e\text{'}p]/[X_t\text{'}]$

where

X_t' is the technical efficient input vector

X_a' is the firm's actual operating input combination

X_e' is economically efficient input vector which is derived by substituting a firm's input prices and statistical noise free output quantity (Q-V) into the demand system.

As argued by the authors this approach avoids the problem of considering all deviations from the frontier as an inefficiency [Bravo-Ureta and Rieger,1991]. Schmidt and Lovell also showed how technical and allocative efficiencies can be estimated from a stochastic production frontier by deriving the cost and input demand functions. Given a Cobb-Douglas technology and the first order condition

$$\ln\left(\frac{X_i}{X_n}\right)=\ln\left(\frac{\alpha_i W_n}{\alpha_n W_i}\right)+\varepsilon_i, i=1,2,\ldots,n-1 and \varepsilon\sim N(0,\sigma_\varepsilon^2)$$

a stochastic cost frontier can be estimated by the following equation

$$\ln(W'X)=\beta_0+\frac{1}{r}lnY+\sum_{i=1}^{n}\left(\frac{\alpha_i}{r}\right)\ln W_i-\frac{1}{r}(V-U)+E where r=\sum\alpha_i.$$

This equation can be estimated by maximum likelihood method and TE can be estimated from (1/r)U ≥ 0 and AE from E ≥ 0 [Schmidt and Lovell,1979].

The achievement in estimating firm specific efficiency levels from stochastic frontier functions has given the profit function a new dimension. Nowadays, the stochastic profit frontier functions which can be estimated by method used to estimate stochastic frontier functions have become one of the most convenient approach in measuring firm specific efficiency especially under transaction costs [Sadulate and Janvry, 1995, p.255]. Profit efficiency as we have seen above is defined as "the ability of a farm to achieve the highest possible profit, given the prices and levels of fixed factors of that firm" [Ali and Flinn, 1989, P.304].

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, p.309]. Many researchers have been exploiting these good 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; 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, we have reviewed concluded that education (both formal and informal) is positively related with efficiency. Let us see some of the conclusions made by different authors for various countries in the world.

"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 producers in pakistan Punjab, Ali and Flinn, 1989, p. 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, p. 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, p. 708].

However, one study conducted by Kalirajan and Shand for Tamil Nadu rice farmers conclude that:

"a) Productivity differences occurred (they mean TE) not because of differences in educational level among farmers, but because of variation in understanding, and b) that formal schooling and understanding were independent of each other....Education didn't show any significant relationship with productivity differences" [Kalirajan and Shand, 1984, p.238].

These authors reviewed related studies conducted before 1984 and argued that the positive relationship reported by many researchers is due to measurement error. In their words:

"Our analysis suggests that the significant relationship between education and productivity in most of the studies cited earlier may arise mainly from the lack of a suitable variable (understanding of cultural practices, non-formal education) measuring differences in knowledge of best practice techniques among farmers" [Kalirajan and Shand, 1984, p. 240]

As the case of 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 and Ali and Chaudhry, 1990; Asefa, 1995 for detail].

3.3.5 Related Studies on the Ethiopian Case

The first study we have reviewed on the Ethiopian case is the work of Sisay Asefa. 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 :

> "A considerable gap exists between the actual and the optimal resource allocation, on the average for the four area farmers. Peasant farmers can increase net farm income, resource use, and productivity under the optimal plans compared to the actual resource allocation. The results show that, compared to the actual farm plan, the optimal farm plan shows an increase of 30.4 percent to 75.4 percent in farm income, 21.5 percent to 40.7 percent in land productivity, 32.1 percent to 57.1 percent in labour productivity and 109.3 percent to 137.3 percent in net returns per unit of capital" [Sisay, 1983, p.132].

Alemayehu Seyoum also tried to measure the technical and allocative efficiency of two 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, p.59]. He has also tried to measure the AE of the farmers using the relation

$$k_i=\beta_i\frac{Y}{X_i}P_i$$

where

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

P_i is the price of the ith input in terms of 'teff' and Y and X_i are output and input i.

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 labour use low income groups are allocatively more efficient than high and low income group and in land use all groups are allocatively inefficient since the corresponding K values are higher than one [Alemayehu, 1989].

The other latest works on these areas are the work of Assefa in 1995 and Abrar,1996. Both concentrated on TE aspect of efficiency due to various reasons. Assefa Followed the three stage procedure to test the impact of education on TE of small holders in Ada and Baso and Worana woredas. First he formulated a stochastic frontier production function with composed errors and then he estimated the coefficients using the maximum likelihood technique. At the final stage he transformed the estimated efficiency indices(which are distributed between 1 and 0)to the range of $-\infty$ to $+\infty$ by using the formula

TO =ln(TE/1-TE)

where TO is the transformed efficiency index. Then he estimated the following multiple regression equation to identify various socio-economic and demographic factors that contribute to farm level technical efficiency differentials.

$$TO = \beta_0 + \sum \beta_i X_i + \epsilon$$

where TO is the transformed value of TE index,

X_i are various socio-economic and demographic variables

ϵ is the radon error term.

Then he concluded that "Secondary school education, oxen, time of fertilizer delivery, and extension contact are the most important factors influencing technical efficiency in Ada Sub district". [Assefa, 1995, P. 192]. By using the same procedure Abrar identified differences in technical efficiency among his sampled farmers and he attributed these variations to differences in farmers' socio-economic factors such as farm and household size, age, and the level of off-farm activities [Abrar, 1996, P.7].

CHAPTER FOUR

DATA AND METHODOLOGY

4.1 SOURCES OF DATA AND THE STUDY AREA

4.1.1 Sources of Data

The main data base for this study is the Ethiopian Rural Household survey conducted by the Economics Department of the Addis Ababa University, in collaboration with the Centre for the Study of African Economies, Oxford University (CSAE), in 1993/94. The data collected cover wide socio-economic aspects of the rural life ranging from HH composition and asset position to agricultural production and input utilization. The data were collected on three rounds by trained enumerators supervised by the staff of the department of economics using fairly well designed and presented questionnaires. However, since the main source of this study is the result of the first round survey (the first experience of the enumerators), some minor errors in recording interview results and /or in data entry were identified. For instance, two or three HHs who cultivated 4-5 gasha (160-200 hectares) of land were reported in Sirbanagudite and Debre Berehan PAs and 1 or 2 kgs of output from more than 1 hectare of land was recorded for some HHs in 4 or 5 PAs. The main reason for such incredible figures is suspected to be the coding system. Therefore by critically examining such errors an attempt has been made to correct them. This seems a better alternative rather than deleting them since the sources of the errors are clearly identified. Some similar minor adjustments have also been done in other variables.

The other source of data for this study is the result of the data collected by the researcher from various woredas of the country in which the sample PAs are located. The main interest of the survey was to collect data that enable us to construct two variables, namely, environment (level of development of the PAs) and extension (extension contact of the farmers) since the survey does not contain enough information on these variables. The field work complemented by various supplementary reports of the Rural Survey and other secondary sources was successful enough in constructing the environment variable (see section 4.2.1 for the details) but not in the case of the extension contact variable. Therefore the extension contact variable is not considered in this study albeit it is one of the major component of informal education.

4.1.2. Sample Size for the Study

Overall, 15 PAs were deliberately selected and covered by the survey. Eight PAs namely, Adele Keke, PAs around Deber Berhan, Dinki, Doma'a, and Korodegaga had been surveyed by International Food Policy Research Institute [IFPRI] in 1989, and they were reselected for the 1993/94 survey in order to generate panel data. The rest 7 PAs, Aze Deboa, Geblen, Haresaw, Imdibir,Sirbana Godeti, Trufa Kechema and Yetmen were added in the 1993/94 sample mainly to cover the major farming systems of the country since the sights covered by IFPRI were all in drought-prone areas. In each PA, a random sample of about 100 HHs were selected giving a total sample of around 1500.

In terms of sample size utilization the study can be readily divided into three parts. In the first and second part where an attempt is made to measure the impact of education on both allocative and technical efficiency of farmers and the problem of selectivity bias, both the number of PAs and the number of HHs in the selected PAs are reduced for reasons to be discussed below. In the third part where the main concern is to analyze the influence of education on the adoption of modern inputs under different environments, all the PAs (except Imdibir, where fertilizer is not generally recommended) and the HHs covered by the survey are included in the study. The main criterion to include a PA in the first and second analyses is the number of HHs in the PA who used fertilizer and hired labour in 'meher' 1993. Based on this criterion, Adele Keke, Debre Birhan (specifically Kolomargefia), Sirbana

Godit and Trufa Kechme PAs are selected. These PAs with all sampled HHs (322 HHs) are taken to be'sub-sample 1'. At the same time individual HHs in these PAs can be divided into two groups. Group 1 represents those who used both fertilizer and hired labour inputs in 'mehere' 1993 and group 2 those who did not use these inputs. Then from the total sample of 322 HHs in the 4 PAs, group 2 is deleted to create 'sub-sample' 2. Group 2, i.e., HHs who did not use fertilizer and hired labour inputs in 'meher' 1993, is deleted in the analysis of the profit function mainly for the following reasons.

1. "TE is the ability of a firm to achieve maximum possible output with **available** resources, while allocative efficiency refers to the ability to contrive an optimal allocation of **given** resources" [Ali and Chaudhry,1990, p.62].

The two bolded words from this simple definition of efficiency revel that we have to calculate efficiency indices for farms (firms) who use the same level of technology. In other words, it gives little sense to compute the efficiency of farmers who do not use improved inputs based on the frontier function estimated by the combination of users and non users of modern inputs. For instance Assefa divided farmers in to two; fertilized and non fertilized, before estimating a stochastic production function for Baso and Worana woreda. To quote him:

> "Out of the 99 farms in Baso and Worana woreda, 58 have used mineral fertilizer, while the remaining 44 farms did not apply fertilizer during the season. Therefore, these two types of farms were treated as separate sub samples categorized and labelled as fertilized and un fertilized farms. It would be ideal to estimate separate production function frontiers for these two types of farms ...because it is possible that these two types of farms may not be represented by a single production frontier" [Assefa, 1995, p.121-122]

2. In the case of the modified (Y-L) profit function model, testing the equality of relative economic efficiency of literate and illiterate farmers implicitly assumes that the profit functions of the two groups differ only in terms of their constant terms.

3. In addition to these conceptual reasons, it is difficult to compute profit for those HHs who do not totally have variable costs (in our case fertilizer and hired labour cost).

The next important question is what is the likely effect of this deletion on the estimated coefficients. In econometrics terminology what would be the impact of selectivity bias problem on the coefficients to be estimated.

The problem of missing observations can arise due to two main reasons. First, data may not be available for a specific group of the sample under considerations for reasons beyond the scope of the researcher. And if these reasons do not have any systematic relation(s) with the included ones, according to Griliches, the problem of selectivity bias can be ignored. Green also concluded that "If this is the case (our first case), the complete observation in the sample constitute usable data set, and the only issue is what possibly helpful information could be salvaged from the incomplete observation [Green, 1995, p.273, see also Griliches, 1986, vol.3].

The second case arises if the members of the sample under consideration are 'self selected'. In such situations the problem of selectivity bias has to be addressed. This case is similar to our case since deletion of unfertilized and non users of hired labour put us in 'selectivity bias' trap.

The problem can be presented algebraically as follows.

Let $\mathbf{Y} = \alpha_i \mathbf{Z}_i + \mathbf{V}_i$ ...(1)

$\Pi = \beta_j \mathbf{X}_i + \mathbf{U}_j$ ...(2)

where

Y = a dummy variable which takes 1 if a HH uses both inputs and 0 otherwise.

π = restricted profit for users of fertilizer and hired labour and observed only when $Y > 0$

Z_i = the i factor which affects the decision of the farmer to use hired labour and fertilizer

X_j = factors that affect that profit of farmers

v_i and U_i = stochastic error terms

α_i & β_j = Parameters to be estimated

Then as argued by Falaris if V_i and U_j "are correlated, estimation of (2) by OLS will result in sample selection bias" [Falaris,1995, p. 335]. However, following Green (1995) we can estimate the expected value Π given the sample rule that Π is observed when $Y > 0$.

$$E[\Pi/\Pi \text{ is observed}] = E[\Pi/ Y > 0]$$
$$= E[\Pi/V_i > -\alpha_i Z_i]$$
$$= \beta_j X_j + E[U_j/V_i > -\alpha_i Z_i\}$$
$$= \beta_j X_j + \rho\sigma_U \lambda(\theta V)$$
$$= \beta_j X_j + \beta_\lambda \lambda_i (\theta V),$$

$$where\theta V = \frac{-\alpha_i Z_i}{\sigma V} and \lambda(.) = \frac{\phi(\alpha_i z_i/\sigma_V)}{\Phi(\alpha_i Z_i)/\sigma_V)}$$

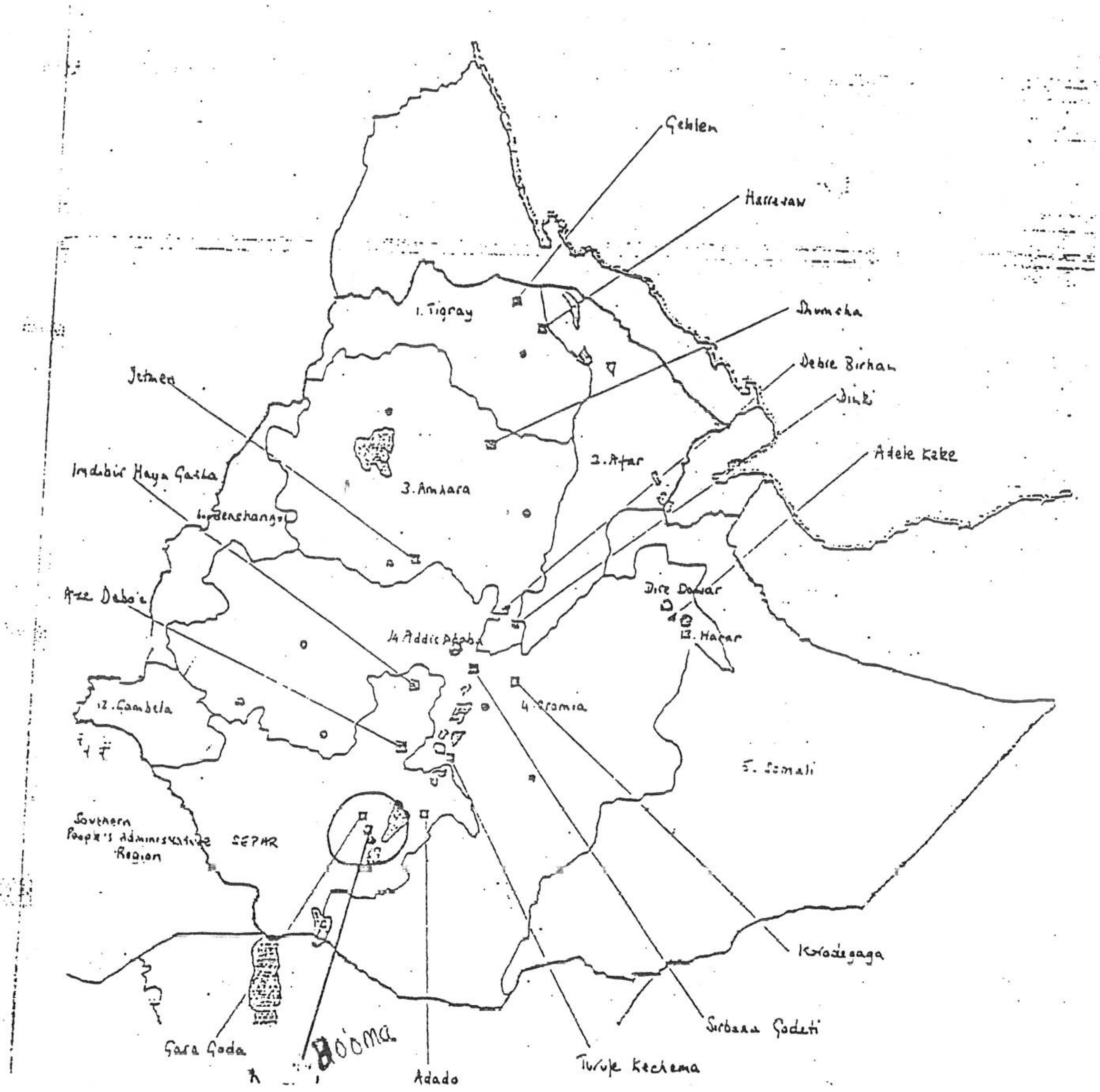
Therefore $\mathbf{\Pi/Y > 0 = \beta_i X_i + \beta_\lambda \lambda_i(\alpha V) + E_i}$...(3) [Green, 1995, pp.709-710]

The new variable λ_i in (3) is the Inverse Mill's ratio and can be called the selection correction variable and its coefficient β_λ measures the selection bias. "A non zero estimate of the coefficient 'λ_i' is evidence of sample selectivity" [Falaris , 1995, p.335]. At the same time if the education variable is included in equation (1) and (2) above and if it is significant and positive in both cases, the impact of education will have two dimensions. First it increases profit indirectly by increasing the probability of the farmers to use modern inputs and secondly by its positive influence on profit within users of modern inputs.

4.1.3. Socio-economic Features of the Sampled PAs.

The specific location of the sampled PAs in space is presented in Map 1. As the map reveals, the sampled PAs are widespread almost all over the country and can be representative for the whole of Ethiopia. In terms of the current political division of the country 5 of the PAs are located in Southern Ethiopian People Administrative Region [AEPAR], 4 in Amhara and in Oromia each, and 2 in Tigray regions. In terms of population size Gara Gooda PA stands first followed by Aze deboa and Adele Keke. The first two of these PAs are located in the most densely populated parts of the country. The rain fall modality, the main crops grown, and the innovations adopted in the PAs are presented in tables 4.2 and 4.3. Fifty four per cent of the sampled PAs are unimodal and the rest are bimodal. This implies that there is no 'belg' output in almost 46 per cent of the sampled PAs. This compels us to concentrate mainly on 'meher' season only (see section 4.2.2).

The method of cultivation technology is almost similar all over the PAs except in some PAs located in SEPAR, where hand hoe is most dominant. Fertilizer, fruit trees, sweet potatoes, soil conservation practices and the like are considered as new innovations in most of



Map 1. Location of Sampled Peasant Associations

the PAs. The main problems in crop and animal production are almost similar across the PAs. Scarcity of land, un reliability and un predictability of the rainy season, frost, disease(mainly of permanent crops) are the main problems in crop production in the survey areas. Animal diseases such as anthrax and shortage of grazing lands were the leading

Table 4.1. The Regional Distribution of the Sampled PAs, 1994

No PA	Name of the PA	Region	Zone	Woreda
01	Adado	SEPAR	Gedeo	Yirgachife
02	Aze Deboa	SEPAR	Kembata	Kedia Gemila
03	Do'oma	SEPAR	N.Omo	Derimalo
04	Gara Goda	SEPAR	N.Omo	Bolosso
06	Debre Birhan	Amahara	N.Sewa	Debre Birahan
07	Dinki	Amahara	N.Sewa	Ankober
08	Shumsha	Amahara	N.Wello	Bugna
09	Yetmene	Amahara	E.Gojam	Enemay
10	Adele Keke	Oromia	E.Harerg	Kersa
11	Korodegaga	Oromia	Arssi	Dodota
12	Sirbana Godeti	Oromia	S.Shewa	Adda
13	Trufe Kechema	Oromia	E.Shewa	Shashemene
14	Geblen	Tigray	E.Zone	Subhasasie
15	Harresaw	Tigray	E.Zone	Atsbi

Source : Bevan,p. and A. Pankhurst (ed) Ethiopian Village Studies, 1995.

problems in animal production in most of the PAs. The other features of the PAs are presented in appendix 1 and discussed in section 4.2.1 where we attempt to classify sample PAs into modern and traditional.

Table 4.2 Physical and Demographic Characteristics of the Sampled PAs

No PA[1]	Total population	No.of HHs	No.of HHs surveyed	Mean annual rain fall	Rain fall modality
01	1803	365	133	n.a	bimodal
02	6444	843	75	1225*	bimodal
03	n.a	277	73	550*	unimodal
04	13825	1750	95	1300**	bimodal
06	n.a	n.a	183	1300**	bimodal
07	643	138	87	700**	bimodal
08	2583	896	146	n.a	bimodal
09	562	n.a	61	n.a	unimodal
10	4500	1300	97	1200**	unimoda
11	1400	304	108	600**	unimodal
12	1990	180	97	860*	unimodal
13	2674	449	103	n.a	bimodal
14	2637	675	66	n.a	unimodal
15	4000	1100	83	425**	unimodal

* For 1993/94 ; ** For 1989/90 ; n.a = not available

1. No. of PAs are as indicated in table 4.1

Source: Computed from the 1993 Ethiopian Rural HH Survey and Bevan,P. and A. Pankhurst,(ed) Ethiopian Village Studies,1995.

Table 4.3 Economic Profile of the Sampled PAs

No Pa*	Main crops	Main Technology	Innovation
01	enset, coffee	iron hoe	maize,beans,wheat,banana,chat
02	enset, coffee	hand hoe ox-plough	fruit trees,soil conservation,ox-plough
03	Tubers, maize	hand how' ox-plough	ox-plough,new crop varieties,ditch digging
04	barley, tubers	hand hoe, ox-plough	ox-plough
06	barley, beans	ox-plough	animal vaccination ,improved seeds
07	millet, teff	ox-plough	fruit tress, vegetable
08	teff, sorghum	ox-plough	vaccination of live stock
09	teff, maize	ox-plough	New crop varieties ,fertilizer, trade
10	sorghum, maize	ox-plough, hand hoe	new crop varieties ,soil conservation, fertilizer
11	maize, beans	ox-plough	fertilizer, improved seed
12	teff, wheat	ox-plough tractor	fertilizer, tractor
13	wheat, barley	ox-plough	fertilizer, improved seed
14	barley, maize	ox-plough	fertilizer
15	barley, wheat	ox-plough	soil conservation, fertilizer

* No. of PAs are as indicated in table 4.1

Source: Bevan, p.& A. Pankhurst, (ed), Ethiopian Village Studies,1995.

4.1.4. Measurement of Variables

1. The following variables are defined for the whole sample.

1.1. **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. The output of perennial crops such as 'chat', banana, 'enset' ,coffee, etc., is not included in this study mainly because adjustment for these crops can not be analyzed from one year cross section data. This is also true for fixed inputs [See Ali and Chaudhry,1990]. Only 'meher' output is considered so as to be consistent for all PAs since nearly half of the PAs in the sample do not have 'belg' output. Due to lack of data farm specific output prices are not used. Instead output prices are taken from the reports which complement the survey. Whenever price data is not available for a particular PA from the report, the nearest PA prices are used. If this is not the case, the price reported by CSA (Prices of goods and services in selected rural areas) for the zone in which the PA belongs is used.

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

1.3. **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.

1.4. **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 is used to define the oxendays variable. All types of labour in ploughing is added together and is multiplied by 2 to get oxendays. Since this variable is the linear combination of the labour input there might be multicollinearity problem.

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

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

1.6.1. a) Educated 1 or literate 1 : 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) Not educated 1 or illiterate 1 : This variable takes 1 if the educated 1 variable is 0 and 0 otherwise.

1.6.2. c) Educated 2 or literate 2: Reading or writing may not have significant impact on adoption of new technology and/ or on agricultural efficiency. Therefore another variable is defined. In this second case education is a dummy variable which takes 1 if any permanent member of the HH completed primary education and 0 otherwise.

d) Not Educated 2 or Illiterate 2 : This is also a quantitative variable which takes 1 if the educated 2 variable is 0 and 0 otherwise.

Therefore the meaning of the term literate or educated farmers varies according to the variables defined above. In case of educated 1, literacy is defined as the ability of any permanent member the HH to read or to write. Members of the HH with ALPC are also considered as literate. In the second case, literacy is defined as a minimum of 6 years of formal schooling.

1.7. **Asset**: This variable is defined as the sum of current values of all furniture, farm implements and other equipments (except fire arms) owned by the HH in Birr. The current value of these items was estimated by the respondents themselves. 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.

1.8. **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' lands 1 is given. Since a particular HH may have more than 1 piece of lands an average of the above dummies is taken. If the average is greater or equal to 0.75 the variable takes 1 and 0 otherwise.

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

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

1.11. **Adoption of fertilizer** : This variable shows whether the HH used fertilizer or not during the main season of the survey. It is 1 if the HH used fertilizer and 0 otherwise.

1.12. **Environment** (index of development of the PA) : A lot of variables which indicate the social and economic level of the PAs were collected from primary and secondary sources to construct the environment variable and they are presented in appendix 1. The basic steps followed to construct this variable can be summarized as follows.

i. Ten variables were selected out of a range of several variables based on personal judgement. Some variables such as distance of the PA from regional capital and other institutions are not included for the simple reason that they are almost perfectly correlated with the included variables.

ii. The average value of the selected variables were calculated and a value of 1 is given if the value of a certain variable for the PA under consideration is greater than the average (if the variable has positive contribution to development) and 0 otherwise. However, if the variable is assumed to be negatively related to development, 1 is given for values less than the average and 0 otherwise. Variables which are assumed to have positive impact on development are, road accessibility , number of health and school services, number of tin roofed houses, number of radios and number of shops. The remaining variables i.e., distance from A.A. and from the woreda town, and distance from the nearest market are assumed to have a negative relationship with level of development.

iii. A mean value is calculated for each PA based on the result of step (ii).

iv. Finally an average value for the whole PAs (less Imdir Haya Gasha) is computed and any value above the average is considered as relatively modern environment and less than the average as traditional. In other words 1 is given for above average values and 0 otherwise. Note that weighing is not used at each stage since it requires personal judgement or detail investigations to attach a specific weight.

1.13. **Interaction Variable** : This variable is defined as the education-environment interaction variable. It is created simply by multiplying the education variable by the environment one.

It helps us to asses the impact of education on adoption of fertilizer under different environments.

2. The following additional variables are defined for sub-sample 2.

2.1. **Restricted profit**: Value of total output in Birr (as defined by 1.1) less cost of variable inputs in Birr (cost of hired labour and fertilizer). 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, 1981; Pudasaini, 1982; Bravo-Ureta and Rieger, 1991]. Other variables such as seed, chemicals, etc., are not considered because either they are complementary to other inputs or their size is negligible. The restricted profit is not normalized since we are dealing with multi prices. This is also true for the wage and the price of fertilizer variables.

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

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

2.4. **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.

2.5. **Price of fertilizer**: It is estimated by dividing the total expenditure on fertilizer by the amount of fertilizer purchased in kg.

2.6. **Pre harvest labour cost**: Only few data are available on payments for pre harvest labour and not at all for family and traditional labour. This compels us to use the total wage rate value to compute the pre-harvest labour cost in all operations. Admittedly, it is a crude approximation but data limitations preclude us from going further in measuring this key variable. However, the assumption used to measure this variable is not very far from reality compared to other studies which used country average wage rate data [for instance see Akridge, 1989 and Bravo-Ureta and Riger, 1991]. 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. This variable together with cost of fertilizer is subtracted from the value of output to make the profit level stochastic.

The descriptive statistics for some of the variables are presented in table 4.4 below. Mean value of output was Birr 2773.89 with standard deviation of 1970. The maximum size of land was 3.76 hectare and the minimum was 0.75. The highest deviation from the mean is observed in output followed by profit and asset. The mean and the median are roughly equal in the case of price of fertilizer, wage and fertilizer (in kg) variables. Some of the variables are not normally distributed as shown by the Bowley's and the Psedudo results presented in Appendix 2. To solve this problem we use a log transformation. Log transformation is preferred to other forms of transformations since logarithms have a property of shrinking the distance between two or more points (provided they are positive) and working with log of a data is easier for interpretation.

For these reasons we transformed our data using logarithms. The Bowles's and the Pseudo ratios, presented in appendix 2 show that the log transformation helps greatly in reducing the non normality of the variables. The absolute value of the Bowles's coefficient of skewness for the transformed data is less than the raw data and the Pesedo deviation is almost equal to the standard deviation of each variable indicating normal tails.

Table 4.4. Descriptive Statistics for Some Important Variables in Sub-Sample 2.

Variables	Mean	Median	Max	Min
land in hectare	3.8	2.2	3.76	0.75
family and traditional labour in man days	216.2	113.5	2010.0	0.00
hired labour in man days	70.3	25.0	1459.0	0.23
asset in Birr	522.0	187.6	5897.0	6.00
fertilizer in kg	139.3	100.0	600.0	25.0
cost of fertilizer in Birr	202.5	162.5	700.0	25.0
value of output in Birr	2773.9	2204.0	12495.0	533.0
profit in Birr	2414.0	1889.5	11422.0	208.5
pre harvest profit in Birr	2839.6	2233.8	11726.2	21.0
wage rate in Birr/ man days	4.9	3.7	22.7	0.18
price of fertilizer in Birr/ kg	1.6	1.5	3.6	0.75

Source : Own computation

4.2. METHODOLOGY

4.2.1 Scope of the Study

Education may have an effect on AE alone, TE alone, scale efficiency alone or on a combination of these efficiency indices. In this study an attempt is made to estimate the impact of education not only on TE as is the case in most of the studies in Ethiopia so far but also on AE. As we have seen in chapter 3 measuring AE is bounded with many theoretical and empirical problems. However, in this study an attempt is made to measure the impact of education on AE in addition to on TE, basically for the following reasons.

1. Many of the researchers who neglected AE were greatly influenced by the 1964 'poor but efficient' hypothesis of Theodore Schultz. Schultz hypothesized that "there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture" [Schultz, 1964, p. 37]. Most researchers who have used production

function techniques to analyze efficiency in the peasant agriculture after 1964 concluded that traditional farmers are efficient but poor [Welch, 1965; Hopper, 1966; Sahota,1968]. However, a critical examination of the evidences presented by the above researchers revealed that there was significant allocation inefficiencies in the peasant agriculture. For instance, Shapiro after reexamining the results upon which the conclusion of 5 different studies were based concluded that :

> "The average D (the relative change in the best estimates of marginal value product that is required to equate it to marginal factor cost) is .41. ...An average of .41 means that, on average, farmers should have reallocated resources so as to cause a 41% change in their marginal value products. This may indicate major deviations from AE, and yet all the above authors conclude that their tests confirm Schultz's 'poor but efficient' hypothesis. Such conclusions and their general acceptance in the profession are indeed puzzling" [Shapiro, 1982, pp.183-184].

2. It is not only AE, if at all, bounded with theoretical and empirical problems. For instance, measurement of TE using stochastic frontier model yields different efficiency estimates for each farm at different time periods. "Thus, TE is somewhat ephemeral, relating only to the technology available in a given year or at a given point in time" [Dawson et al., 1991, P.1099]. Moreover, the estimation of TE requires the assumption of maximality, and a combination of one sided and two sided error terms. However, as argued by Førsund et al.,

> "this assumption implies some other inputs or external effects have maximal possible effects, but others have potentially unbounded effects. ... It is 'also' possible to argue that there is not an optimal value of any thing, and hence there is no reason for a one-sided error or error component. In this view the concept of maximality is discarded. Thus, there is not yet a consensus on how one should, or whether one can,measure the TE of a firm,even if this is agreed to be a useful thing to measure" [Førsund et al.,1980, p.23].

3. There are very high productivity differences among farmers and these differences are widening through time. Researchers have identified three broad sources of productivity differences: resource endowment differences, differences in technology embodied in fixed or working capital and differences in human capital which includes education, skill and knowledge [Haymi & Ruttan,1970]. Therefore, if the main concern of the study is to analyze the impact of human capital on efficiency, the allocative efficiency aspects of economic efficiency can not be neglected without much more problem than the problems associated with its inclusion. It is also argued that the allocative effect of education from the total productivity is much higher in agriculture where allocative decisions are continuously made than in other industries where the large portion of the work force does not engage in decision making activities [Welch,1971]. Welch stressed that:

> "In most industries jobs performed by persons with different education are more sharply differentiated than in agriculture, and, in these cases, the physical productivity of education is more easily understood. In agriculture, differences in job complexity associated with differences in education are less noticeable , and the product of education is more likely to be associated with AE. Allocative ability plays a key role in determining education's productivity in agriculture" [Welch, 1971, p,40].

Huffman also found a $ 6.08 impact of education on TE and $10.4 on allocative efficiency in US agriculture on the adoption of chemical fertilizer alone [Huffman,1974].

4. The importance of AE is also very high if one relaxes the assumptions of free and perfect knowledge and rationality since farmers uncovered with such classical assumptions are most likely to make allocative errors.

Concerning this Pudasaini explicitly stated that:

> "Education may enhance farmers' ability to acquire and analyze technical and market information about inputs and enable them to adjust quickly to disequilibria in input use. Consequently education may have a much stronger impact on output through its allocative effect than through its worker effect" [Pudasaini,1983, p.48].

In addition to this, after intensive research in New England dairy industry, Bravo-Ureta and Rieger concluded that "focusing only on TE as the applied studies of dairy farm efficiency have considerably understates the potential gains that could be derived by individual farmers as well as society from improvements in overall performance" [Bravo-Ureta and Rieger, 1991, p.422].

5. The other serious problem in measuring AE in cross- sectional framework is the absence of market prices for some inputs and even if available its invariability across observations. Biased and inconsistent estimates of coefficients because of simultaneous equation bias are additional problems. However, these problems can be reduced by dropping households for whom price data are not available and by taking samples from areas which are dispersed in location. The possibility of selectivity bias and the correction mechanisms are discussed in this chapter. The simultaneous equation bias can be alleviated by simultaneously estimating the profit function with factor demand equations or by assuming that farmers maximise expected profits rather than actual profits [Yotopoulos and Lau,1973 Huffman, 1977; Pudasaini, 1983; Levy, 1981; Ekayanake, 1987; Ali and Flinn, 1989; Bravo-Ureta and Rieger, 1991; Kalirajan, 1992]. Therefore, in this study an attempt is made to measure the impact of education on both allocative and technical efficiency of farmers.

4.2.2. Model Specification

Proving the existence of TE and/or AE differences in the sample farmers is the first task of a study like this. This is because it does give little purpose to analyze the impact of other variables such as education on efficiency if there is no efficiency difference at all or if it is very narrow.

Under conventional economic theories where farmers are assumed to face the same level of input and output prices, identical technology and have equal profit maximization motivation, efficiency differentials may not be expected. However, the reality is quite different. 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 fertilizer, 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 to one another lead to efficiency (both TE and \ or AE) differentials. Kalirajan argued that "In practice, it is found that firms produce the same output with varying factor intensities because, even assuming they want to maximize profits, they face different fixed factors of production, such as technical knowledge, land and socio-economic environment" [Kalirajan, 1992, p.308].

Therefore, in this study it is hypothesized that there are profit efficiency differentials in the sampled farmers. To test this hypothesis the following model is specified.

$$\ln\pi_2 = \alpha_0 + \sum_{i=1}^{n} \beta_i W_i + \sum_{j=i}^{m} \delta_j Z_j + U + V \ldots (1)$$

where

π_2 = pre harvest profit
W_i = Price of variable input i ,i= 1,2,...n,
Z_j = fixed input j, j= 1,2,... m,
V = a symmetric error term which is assumed to be iid $N(0,\sigma^2_v)$
U = A negative random variable which is assumed to measure the level of profit inefficiency and
α_0, β_i,δ_j are parameters to be estimated.

This equation is estimated by MLE.

Then, following Battesa and Corra, we test the hypothesis that the divergence of actual profit from the maximum profit is due to random factors rather than difference in efficiency, i.e.,

Ho: $\gamma = \sigma_U^2/(\sigma_U^2 + \sigma_V^2) = 0$

If the null hypothesis is not rejected it implies that there is no statistically significant relative profit efficiency difference among the farmers in the sampled PAs and if exists it is accidental. If $\gamma = 0$ it shows that " σ^2_u is zero and hence the U term should be removed from the model" [Coelli ,1994]. This implies that there is no systematic mistake committed in the sample PAs by technical inefficiency or by under or over utilization of variable inputs. This in turn implies that it makes little sense to study factors that affect efficiency differentials.

Once the existence of efficiency differences among the sampled farmers is proved the next task is to examine the influence of education on these efficiency differences, which is the main concern of this study. Two different models are specified to this end. First the following modified Y-L type of profit and input demand functions are estimated.

$$\ln\pi^* = \ln\alpha_o + \delta^L D^L + \sum_{i=1}^{n} \beta_i W_i + \sum_{j=1}^{m} \delta_j \ln Z_j + \beta_\lambda \lambda + E_i \ldots (2)$$

$$-\frac{W_i X_i}{\pi^*} = \beta_i^L D_i^L + \beta_i^I D_i^I + \beta_{\lambda i} \lambda_i + V_i \ldots (3)$$

where π^* 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 illiterate farmers and 0 otherwise, λ is the selection correction variable as discussed in section 4.1.2, E represents omitted variables, exogenous factors and other statistical errors, V represents divergence between realized and expected prices and i represents the i^{th} HH. To estimate equations (2) and (3) above we need to make assumptions about the relationships among the error terms. To do so we have to first see the problem of estimating systems of equations like these which are apparently un correlated or seemingly uncorrelated.

At first sight one may conclude that the above equations can be estimated by OLS since none of the variables on the right hand side of equations (2) & (3) are endogenous. However, despite the fact that " OLS estimate of these equations would be consistent and unbiased, the estimation method developed by Zellner (1962) for Seemingly Unrelated Regressions (SURE) provides estimates that are more efficient" [Sadulate and Janvry, 1995, p.45]. Maddala showed that given the following recursive equations:

$$Y_1 + \beta_{12}Y_2 + \beta_{13}Y_3 + \alpha_1 Z_1 = U_1$$

$$Y_2 + \beta_{23}Y_3 + \alpha_2 Z_2 = U_2$$

$$Y_3 + \alpha_3 Z_3 = U_3$$

if U_1, U_2, and U_3 are independent each equation can be estimated by OLS. If, however, U_2 and U_3 are correlated but not with U_1 the model will be 'block recursive' and the last two equations have to be estimated jointly [Maddala, 1992, p.387]. Dwivedi and Srivastava have also proved that the higher the correlation among the disturbance terms, the greater will be the efficiency gain from using SURE rather than OLS. However, in cases where the set of explanatory variables are the same in all equations and where the independent variables in some equations are subsets of those in another equation SURE does not bring any efficiency gain [Dwivedi and Srivastsva, 1978; Kementa, 1990, p.635; Greene, 1993, pp.488-489]

The basic estimation procedure of SURE is summarized by Sadoulet and Janvry and the mathematical derivation is given by Greene [See Sadoulet and Janvry ,1995, p.45; Green, 1993, pp.488-490]. However, if there are linear restrictions to be tested, as in our case (see section 5.3), SURE is the only estimation method available. Concerning this Green says "If all equations have the same set of right hand side (dependent) variables and if there are no linear constraints imposed, then SURE is the same as equation by equation ordinary least squares. If linear constraints are imposed, this is no longer true" [Green,1993, p.387].

Using the estimates of equations (2) and (3) twenty six different hypotheses, presented in section 5.3. will be tested. The test result will show whether literate or illiterate farmers are relatively allocatively, technically, and/or economically efficient and which group achieves absolute AE in the utilization of fertilizer and hired labour inputs simultaneously and individually. The coefficients of λ have also interesting implications. If β_λ are significant it is an evidence of sample selectivity bias. However, as we have seen before this approach does not give farm specific efficiency indices and consequently it does not have room to incorporate other non-conventional inputs so as to explain efficiency differentials. Therefore, we estimate a stochastic profit frontier so as to complement the previous model. The form of the function to be estimated is

$$\ln\pi=\ln\alpha_0=\sum_{i=1}^{n}\beta_i\ln W_i+\sum_{j=1}^{m}\delta_j\ln Z_i+\beta_\lambda\lambda+U+V...(4)$$

where all variables are as defined before except the labour input which is now measured in a bit different fashion. Before looking how the labour input is measured, let us see how equation (4) can be estimated in a bias free way. We can not estimate equation (4) directly by OLS unless we incorporate other equations for endogenous variables X_i from the first order conditions of the production function. However, Zelliner, Kementa and Drere showed special conditions upon which equation (4) can be estimated. Maddala based on the above authors' work showed that if we assume farmers to maximize expected profits instead of actual profits it is reasonable to assume that the errors of the production function are independent of the errors of the first order conditions for a given input since the first errors are owing to 'acts of nature'. Under these assumptions the errors of the first order conditions are independent of the errors of the production function. Hence OLS yields consistent estimates of the parameters β_i and δ_j [Maddala, 1992, pp. 387-388].

Therefore in the case of equation (4) we assume farmers are maximizing expected profits. At the same time to be consistent with this assumption we take only pre harvest variable costs (fertilizer and pre harvest labour) so as to make profit level to be determined by inputs applied before harvest. Many researchers also justified their estimation of a single equation by assuming that farmers maximize expected profits rather than actual profit [Lingard et al.,1983; Ekayanake, 1987; Ali and Flinn, 1989; Bravo-Ureta and Rieger, 1991]. Thus fertilizer and cost of pre harvest labour input are used as variable inputs. Therefore, man days of labour applied on harvesting operations are deducted from the labour input. Due to this new way of measurement of the labour input the distinction between family and hired labour is abandoned (see section 4.1.4 for the details).

Using equation (4) we apply the following three stage approach to investigate the impact of education together with other socio-economic and demographic variables on farm specific profit efficiency. First the stochastic profit function specified in equation (4) is estimated using maximum likelihood method. Secondly, farm specific profit efficiency index is calculated from the stochastic profit function following the method developed by Jondrow et al., [1982]. Finally the calculated farm specific efficiency index is regressed on various demographic, social and economic variables.

Testing the impact of education on efficiency under different levels of development (environment) is also very interesting. However, due to lack of data for PAs under different environments we can not do this. But it has been attempted to asses the impact of education on adoption of fertilizer input under different environments. The following two different procedures are followed to this end.

1. The total PAs are divided into two parts, namely modern and traditional based on the methods discussed in section 4.1.4. Then the following probit model is specified and estimated.

$$Y_i = \alpha_0 + \alpha_j X_j, \; i = 0 \, or 1, \; j = 1, \ldots, n$$

where

Y = 1 if the farmer used chemical fertilizer in the survey period and 0 otherwise

x_j = various demographic, social and economic variables which affect the decision of farmers in using fertilizer.

2. An education environment interaction variable is created simply by taking the product of the two variables.

In both cases the environment and the interaction variables have significant implications and as to my knowledge the interaction variable is the first variable to be used in studies like this. This interaction variable is expected to measure whether the two variables are complementary or substitutes in the adoption of fertilizer. If the impact of education on adoption of fertilizer is high in modern environment the coefficient of the interaction variable will be positive and significant. If the converse is true the coefficient will be negative and or insignificant. Therefore, we can not hypothesize the sign of the variable from the outset.

Lockheed et al., tried to capture the impact of education on farmers' efficiency under modernizing and non modernizing environments. They followed two different procedures. First they divided the sample studies they reviewed into modern and non modern environments and they saw how the contribution of education differs between the two areas. The second method they followed has two stages. First they estimated the percentage increase in farm output per four years of education and then they regressed this on variables such as 'adult literacy rate in the country, modernizing environment, regional availability of extension service', etc. [Lockheed et al.,1980]. Huffman also tried to investigate the interaction of education and extension contact variable on the ability of farmers to adjust to disequilibria created owing to price change and technological advances. But he did not treat the impact of education on adjustment to disequilibria under different environments.

In the Ethiopian case, Tesfai Tecle (1975) and Assefa Admassie (1995) investigated factors that affect farmers' rate of adoption of new technologies such as improved seeds and fertilizers. Tesfai used probit and Assefa semi log models and they conclude that education has a positive and significant impact on adoption of modern inputs. However, since their study was based on one or two 'Woredas', they did not get the opportunity to asses the different impact of education on adoption of modern inputs under different environments.

CHAPTER FIVE

EMPIRICAL RESULTS

5.1 INTRODUCTION

On the basis of empirical data, the results of our analyses are presented and discussed in this chapter. First an attempt is made to examine the existence of inefficiency in the sampled farmers. Then we analyze the impact of education on both allocative and technical efficiency differentials. Finally, the impact of education on the adoption of fertilizer under different environments is analyzed.

As we have seen before, our sample is divided into three groups. The first sample which constitute the whole 15 PAs and the 1474 observations is labeled as the whole sample. The second group which is called Sub-sample 1 consists of the total observations in the sampled 4 PAs. The last group which includes households (HHs) in the 4 PAs who used fertilizer and hired labour is labelled as sub-sample 2. The first group is used to analyze the impact of education on adoption of fertilizer under different environments. Since Sub-sample 2 is derived from Sub-sample 1, there might be selectivity bias problem. Then Sub-sample 1 is considered to test the presence of selectivity bias problem. The last group, namely sub-sample 2 is used to prove the existence of efficiency differentials across farmers and to analyze the impact of education on these efficiency differentials.

5.2. EFFICIENCY DIFFERENCES AMONG THE SAMPLED FARMERS

To prove the existence of efficiency differentials among the sampled farmers the following model is estimated using FRONTIER Computer Program Version 4.1 [Coelli, 1994].

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

where

π_2	=	restricted pre harvest profit in Birr
W_1	=	Wage rate in Birr
W_2	=	Price of fertilizer 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 δ_j are parameters to be estimated.

Then we test the following two hypotheses.

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:

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

The results are presented in table 5.1. The signs of the coefficients are as expected except for the coefficient of the wage variable which turns out to be positive in the MLE. There is also no significant difference between the OLS and ML estimation methods except for this variable. As is usually expected the t ratios and the intercept term are higher in the case of MLE than in the OLS. According to Ali and Flinn, this implies that "MLE envelop function shifts vertically, as opposed to a substantive change in slope of the profit function" [Ali and Flinn, 1984, p.307].

The coefficient of the wage variable takes wrong sign, though insignificant, in the case of the MLE, probably due to measurement error. Other variables take expected signs in both estimation methods. In this section, however, our main interest lies on the value U and γ. The parameter γ is the ratio of the variance of U and the variances of the sum of U and V. A higher mean value of U is an indicator of profit inefficiency. Theoretically the value of γ lies between 0 and 1. A value of γ near to 1 shows efficiency differences among the sampled farmers which is not accounted by random factors.

As is shown in Table 5.1, the value of E[U] is 46 %. The value of γ is also 0.87 and it is significant at less than 1 per cent. Technically these imply 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 there is high profit inefficiency in the sampled farmers. Specifically it shows that on the average there was 46% 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 has also interesting implications. 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 the divergence of the actual practice from the best farming practice.

Table 5.1: Results of the OLS and MLE Estimation of the Profit Function.

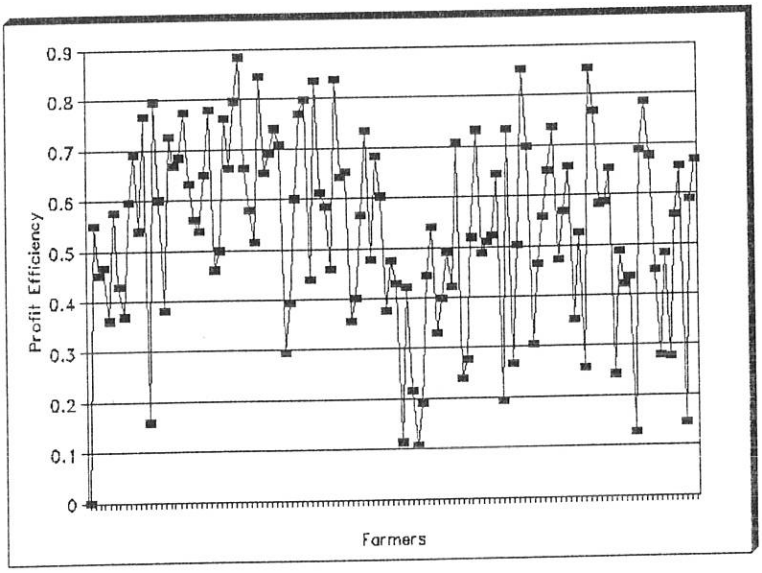
Variables	Parameters	Estimated Values	
		OLS	MLE
Constant	α_0	1.6412* (2.1123)	1.7017* (2.1471)
Wage	B_1	-0.0996 (0.9075)	0.0648 (0.5851)
Price of fertilizer	B_2	-1.1018*** (1.2555)	-0.9956*** (1.2755)
Land	γ_1	0.4060*** (1.2699)	0.4349*** (1.2584)
Oxen days	γ_2	0.2235*** (1.3743)	0.2068** (1.4586)
Asset	γ_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 HHs		120	120

* significant at 1 % , ** significant at 10 %, and *** significant at 15 %

Note : Figures in parentheses are t ratios

Source: Own Computation

Fig. 2. Distribution of Farm Specific Profit Efficiency in Sub-sample 2



Source : Own computation

There is also a wide variation in profit efficiency across the sampled farmers. Table 5.2 and Fig. 2 show this wide variation. Both the figure and the table reveal that farm level profit efficiency ranges from 10 to 88 percent. Specifically the table depicts that 61.7 percent of the farmers have achieved only upto 60 percent of the possible maximum level of profit efficiency and it is only 5 percent of the farmers who achieved more than 80 per cent.

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

5.3 THE IMPACT OF EDUCATION ON ALLOCATIVE AND TECHNICAL EFFICIENCY OF FARMERS

5.3.1. Selecting Estimation Methods and The Problem of Selectivity Bias

In section 5.2 we have tried to show the existence of inefficiency in the sampled farmers and the hypotheses 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 that farm specific characteristics are much more responsible for the inefficiencies rather than factors which are beyond the control of the farmers. However, the observed 46% mean inefficiency may arise from technical, allocative or both inefficiencies. In this section we analyze 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.

$$\ln\Pi_1=\alpha_0+\delta_i D^L_{ik}+\sum_{j=1}^{2}\beta_j \ln w_{jik}+\sum_{j=1}^{2}\gamma_j \ln Z_{jik}+\alpha 1 D_{ik}+\beta_{\lambda 1}\lambda_{ik}+V_{ik}\ldots [2]$$

$$\frac{-W_1X_1}{\Pi_1}=\beta^L_1 D^L_{ik}+\beta^I_1 D^I_{ik}+\beta_{\lambda 2}\lambda_{ik}+\epsilon 1_{ik}\ldots [3]$$

$$\frac{-W_2X_2}{\Pi_1}=\beta^L_2 D^L_{ik}+\beta^I_2 D^I_{ik}+\beta_{\lambda 3}\lambda_{ik}+\epsilon 2_{ik}\ldots [4]$$

Where
K is 1 or 2 based on whether education is defined as educated 1 or 2 respectively
i is the i^{th} HH
j is the j^{th} input
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

W_2 is price of fertilizer
Z_1 is area cultivated in hectare
Z_2 is family and traditional labour in man days
D is soil fertility dummy
X_1 is hired labour in man days
X_2 is fertilizer 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 realized prices respectively, α_o, α_1, β_j and γ_j are parameters to be estimated.

(See section 4.2.1 for definition of variables)

As it has been indicated earlier the above equations can be estimated using the OLS approach if the error terms of the equations are not correlated. Thus, it is necessary to estimate these equations by OLS and check if there are significant correlations among the error terms. Appendix 3 summarizes the results. The two tailed tests reveal that neither of the correlation coefficients is significant at less than 10 percent level of significance. This implies that there is no efficiency gain by estimating the above equations by other methods such as SURE. Therefore, OLS is used to estimate these equations. However, in order to estimate these equations, first, we have to derive the Inverse Mill's ratio variable.

This variable can be generated in two stages. First the following profit model is estimated for Sub-sample 1.

$$Y_0=\alpha_0+\sum_{j=1}^{6}\beta_j X_{ji}+\epsilon_i \ldots [5]$$

where
Y_0 = 1 if the farmer hired labour and used fertilizer and 0 otherwise
X_1 = 1 if the farmer cultivated her/his land and 0 otherwise
X_2 = 1 if the soil is fertile and 0 otherwise
X_3 = Area cultivated in hectare
X_4 = Value of the asset of HH
X_5 = Age of the head of the HH
X_6 = Education of the HH as defined by Education 2
ϵ = The error term
α_o & β_j are parameters to be estimated
(See section 4.2.1 for measurement of variables)

Second, following Heckman (1979) and Lee (1983) λ_i is generated from the Inverse Mill's ratio by the formula

$$\lambda_i = \frac{\phi(\Phi^{-1}(p_i))}{\Phi(\Phi^{-1}(P_i))}$$

Where

P_i = the probability of the i[th] farmer uses fertilizer & hired labour

ϕ = the standard normal density function

Φ = the normal distribution function

Now equations (2), (3) and (4) above can be readily estimated by OLS for the Sub-sample (2). As we have seen in section 4.1.2, if the coefficients of λ_i are significant it is an indication of sample selectively bias and OLS results without λ_i are inconsistent. In other words if β_λ are significant it indicates that sub-sample 2 which is created from sub-sample 1 can't be considered as a random sample drawn form the whole farmer population. Appendix 4 reports the MLE results of the probit model for sub-sample 1 which is the basis for deriving λ_i.

As shown in Appendix 4, except the soil fertility dummy variable, all variables take expected sign. Tenure, the asset position of the HH and education play a significant role in the decision of farmers to use fertilizer and hired labour inputs. The coefficient of the age variable is negative though insignificant indicating that older farmers tend to be slower in adoption and usage of modern inputs.

Now we turn to estimating the profit and the input demand functions, i.e, equations (2), (3) and (4) above which is our main interest. These equations are estimated using LIMDEP econometric software which takes into account the problem of selectivity bias. The result is 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 even at 20 percent except in the fertilizer demand equation in which it is significant at 14%. This implies that farmers who used fertilizer and hired labour inputs and who didn't use these inputs shared the same unmeasurable characteristics. This in turn reveals that sub-sample 2 which is formed based on the adoption of fertilizer and hiring labour inputs 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 [TSLS] Results of the Profit and Input Demand Functions with Correction for Selectivity Bias

Variables	TSLS Estimated
1. The profit function	
Constant	5.8438* (7.473)
Education 2[1]	0.34985* (1.895)
Wage	-0.1046*** (1.284)
Price of fertilizer	-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 fertilizer 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

1. The result is also similar for educated 1 variable.* Significant at 1%, **Significant at 5% and ***Significant at 10%
Note: Figures in parentheses are t ratios
Source: Own computation

5.3.2 Estimated Results of the Profit and the Input Demand Functions and Their Theoretical Consistency

To analyze 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 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 utilization of hired labour and fertilizer inputs:

   Ho: $\beta^L{}_1 = \beta^I{}_1$, and $\beta^L{}_2 = \beta^I{}_2$

3.1. Equal allocative efficiency in hired labour input only:

   Ho: $\beta^1{}_L = \beta^I{}_1$

3.2. Equal allocative efficiency in fertilizer input only:

   Ho: $\beta^L{}_2 = \beta^I{}_2$

4. **Absolute allocational** Efficiency of educated farmers in the utilization of both hired labour and fertilizer inputs:

   Ho: $\beta_1 = \beta^L{}_1$, and $\beta_2 = \beta^L{}_2$

4.1. Absolute allocational efficiency in hired labour input only:

   Ho: $\beta_1 = \beta^L{}_1$

4.2. Absolute allocational efficiency in fertilizer input only:

   Ho: $\beta_2 = \beta^L{}_2$

5. Absolute allocational efficiency of illiterate farmers in the utilization of both hired and fertilizer inputs:

   Ho: $\beta_1 = \beta^I{}_1$, and $\beta_2 = \beta^I{}_2$

5.1. Absolute allocational efficiency in hired labour input only:

Ho: $\beta_1 = \beta^I_1$

5.2. Absolute allocational efficiency in fertilizer input only:

Ho: $\beta_2 = \beta^I_2$

All the above hypotheses are tested by jointly estimating the profit and the input demand functions after the appropriate equality constraints are imposed. However, as we have seen before, OLS is no longer useful since we have linear restrictions. Therefore, SURE is used to jointly estimate the profit and the input demand functions together with the above linear restrictions by limiting the number of iterations to 1 [see Green, 1993].

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. For each restriction the education variable is measured in two different ways. The results presented in Table 5.4 are based on Model 1 in which the education variable is measured interms of reading, writing and ALPC. Table 5.5 summarizes the results based on the second definition of education, i.e., completion of elementary education. Before proceeding to the results of the restrictions, however, it is important to evaluate the estimated functions, especially the basic model results, in the light of economic theory and statistical requirements.

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 since βi, the coefficients of input prices are less than zero in both the profit and input demand functions. The theory also requires the profit function to be a non-decreasing function of fixed inputs. The coefficients of the area and the fixed labour input variables are positive and significant in accord with the requirements of the theory. Thus, in general, the estimated profit and input demand functions satisfy the basic properties of the theoretically accepted profit and input demand functions.

Looking at the coefficients of the variables of the basic models in Tables 5.4 and 5.5, we find that more than 80 percent of the variables are significant at less than 10 percent and no variable takes a wrong sign in all equations. In all of the 26 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 also pick the correct sign and are significant except for price variables which do not do well in some of the equations. In the input demand equations too, the coefficients of all variables come up with the correct sign though in some of the equations the coefficients are insignificant.

Table 5.4. Joint Estimation of the Profit and the Input Demand Functions for Sub-Sample 2: Model 1.

parameter	Basic Models		Hypotheses				
	OLS	SURE	1	2	3	3.1	3.2
α_0	6.73* (16)	6.26* (17)	6.77* (18)	6.71* (19)	6.55* (18)	6.47* (17)	6.49* (17)
δ^L	0.60* (4.0)	0.55* (3.7)	0.00	0.00	0.33* (2.5)	0.42* (3.0)	0.40* (3.0)
B_1	-0.09 (1.1)	-0.02 (0.4)	-0.66 (0.91)	-0.05 (0.6)	-0.03 (0.4)	-0.03 (0.4)	-0.03 (0.5)
B_2	-0.84* (2.7)	-0.29 (1.1)	-0.23 (0.87)	-0.23 (0.87)	-0.41 (1.5)	-0.42 (1.52)	-0.42 (1.5)
γ_1	0.65* (5.7)	0.53* (5.4)	0.51* (5.1)	0.51* (5.21)	0.56* (5.5)	0.56* (5.5)	0.58* (5.5)
γ_2	0.07* (2.2)	0.09* (3.0)	0.09* (3.1)	0.09* (3.14)	0.09* (2.9)	0.08* (2.6)	0.09* (2.9)
D_1	0.19 (1.8)	0.16 (1.8)	0.15*** (1.63)	0.15** (1.7)	0.17**(1.9)	0.17** (1.9)	0.17** (1.9)
B^L_1	-0.06 (1.6)	-0.06 (1.6)	-0.08* (2.1)	-0.12* (3.0)	-0.11*(3.1)	-0.12* (3.1)	-0.79** (1.9)
B^I_1	-0.42* (4.3)	-0.42* (4.3)	-0.32* (3.4)	-0.12* (3.0)	-0.11* (3.1)	-0.12* (3.1)	-0.34* (3.6)
$^{L}_{2}$	-0.10* (10.6)	-0.10* (10.6)	-0.11* (11.3)	-0.11* (12.3)	-0.11* (12.7)	-0.10* (11.1)	-0.11*(12.7)
B^I_2	-0.17* (7.5)	-0.17* (7.6)	-0.14* (6.6)	0.11* (12.3)	-0.11* (12.7)	-0.15* (6.9)	-0.11* (12.7)

Table 5.4 (Continued)

Paramet ers	Hypotheses					
	4	4.1	4.2	5	5.1	5.2
α_o	6.11* (25.9)	6.39* (18.3)	6.07* (21.7)	6.54* (26.8)	6.72* (19.1)	6.13* (22.2)
δ^L	0.53* (3.73)	0.56* (3.9)	0.53* (3.7)	0.42* (3.0)	0.43* (3.1)	0.54* (3.8)
B_1	-0.06** (1.7)	**-0.06** *** (1.6)	-0.04 (0.6)	**-0.18*** (3.1)	**-0.17*** (2.9)	-0.04 (0.6)
B_2	-0.10* (10.8)	-0.40 (1.5)	**-0.10*** (10.7)	**-0.16*** (7.1)	-0.34 (1.3)	**-0.17*** (7.6)
γ_1	0.54* (5.47)	0.55* (5.6)	0.54* (5.4)	0.50* (5.1)	0.52* (5.2)	0.54* (5.5)
γ_2	0.09* (3.3)	0.08* (2.8)	0.09* (3.3)	0.08* (2.9)	0.08* (2.6)	0.09* (3.2)
D_1	0.19** (2.0)	0.17** (1.8)	0.19** (2.0)	0.18** (1.9)	0.17** (1.8)	0.18** (2.0)
B^L_1	-0.60** (1.7)	**-0.06** *** (1.6)	-0.06*** (1.6)	-0.06 (1.6)	-0.06 (1.6)	-0.06 (1.6)
B^I_1	-0.42* (4.3)	-0.42* (4.3)	-0.42* (4.3)	**-0.18*** (3.1)	**-0.17*** (2.9)	-0.42* (4.4)
B^L_2	-0.10* (10.8)	-0.10* (10.7)	**-0.10*** (10.7)	-0.10* (10.6)	-0.10 (10.6)	-0.10* (10.6)
B^I_2	-0.17* (7.6)	-0.17* (7.6)	-0.17* (7.6)	**-0.16*** (7.1)	-0.15* (7.0)	**-0.17*** (7.6)

Bold figures show restrictions.
* Significant at 1 percent , ** Significant at 5 percent
** Significant at 10 percent

Note : Figures in parentheses are t ratios
Source : Own computation

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

Para meter	Basic Model(Without Restrictions)		Hypotheses				
	OLS	SURE	1	2	3	3.1	3.2
α_o	6.87* (16.0)	6.40* (18.3)	6.70* (19.1)	6.71* (19.1)	6.50* (18.2)	6.50* (18.1)	6.48* (18.1)
δ^L	0.32* (2.8)	0.32* (2.9)	**0.00**	**0.00**	0.26* (2.9)	0.26* (2.6)	0.29* (3.1)
B_1	-0.09 (1.1)	-0.00 (0.0)	-0.04 (0.5)	-0.05 (0.6)	-0.01 (0.2)	-0.01 (0.1)	-0.01* (0.1)
B_2	-0.65** (2.0)	-0.18 (0.7)	-0.23 (0.9)	-0.23 (0.8)	-0.27 (1.0)	-0.27 (1.0)	-0.27 (1.0)
γ_1	0.60* (5.0)	0.50* (5.2)	0.51* (5.2)	0.51* (5.2)	0.52* (5.2)	0.52* (5.2)	0.52* (5.2)
γ_2	0.09* (2.6)	0.10* (3.5)	0.09* (3.2)	0.09* (3.1)	0.01* (3.3)	0.01* (3.3)	0.01* (3.3)
D_1	0.24** (2.1)	0.2** (2.3)	0.16*** (1.8)	0.16*** (1.7)	0.22* (2.3)	0.22* (2.3)	0.22* (2.3)
B^L_1	-0.57 (1.0)	-0.06 (1.0)	-0.01*** (1.8)	**-0.11*** (3.0)	**-0.11*** (3.0)	**-0.12*** (3.0)	-0.06 (1.2)
B^I_1	-0.17* (3.2)	-0.17* (3.2)	-0.13* (2.6)	**-0.11*** (3.0)	**-0.11*** (3.0)	**-0.12*** (3.0)	-0.16* (3.2)
B^L_2	-0.11** (8.0)	-0.11* (8.11)	-0.12* (9.6)	**-0.11*** (12.3)	**-0.11*** (12.3)	-0.11* (8.8)	**-0.11*** (12.3)
B^I_2	-0.12* (9.2)	-0.12* (9.3)	-0.10* (8.8)	**-0.11*** (12.3)	**-0.11*** (12.3)	-0.11* (9.2)	**-0.11*** (12.3)

Table 5.5 (Continued)

Parameters	Maintained Hypotheses					
	4	4.1	4.2	5	5.1	5.2
α_0	6.38* (29.6)	6.53* (19.1)	6.32* (25.0)	6.59* (32.7)	6.70* (19.9)	6.33* (25.3)
δ^L	0.32* (2.9)	0.32* (3.0)	0.31* (2.9)	0.27* (2.6)	0.27* (2.6)	0.32* (2.9)
B_1	**-0.04** (0.9)	**-0.04** (0.9)	-0.01 (0.2)	**-0.12*** (2.7)	**-0.11*** (2.7)	-0.01 (0.2)
B_2	**-0.11*** (8.3)	-0.25 (1.0)	**-0.11*** (8.2)	**-0.11*** (9.2)	-0.22 (0.8)	**-0.12*** (9.3)
γ_1	0.50* (5.2)	0.51* (5.2)	0.51* (5.2)	0.48* (5.0)	0.49* (5.0)	0.51* (5.2)
γ_2	0.10* (3.6)	0.01* (3.31)	0.10* (3.6)	0.01* (3.4)	0.01* (3.2)	0.10* (3.6)
D_1	0.22* (2.4)	0.22* (2.3)	0.22* (2.4)	0.22* (2.3)	0.21* (2.3)	0.23* (2.4)
B^L1	**-0.04** (0.9)	**-0.04** (0.9)	-0.06 (1.0)	-0.08 (1.0)	-0.05 (1.0)	-0.06 (1.0)
B^I_1	-0.17* (3.2)	-0.17* (3.2)	-0.17* (3.2)	**-0.12*** (2.7)	**-0.11*** (2.7)	-0.17* (3.2)
B^L_2	**-0.11*** (8.3)	-0.11* (8.2)	**-0.11*** (8.2)	-0.11* (8.1)	-0.1* (8.1)	-0.11* (8.1)
B^I_2	-0.12* (9.3)	-0.12* (9.3)	-0.12* (9.3)	**-0.11*** (9.2)	-0.11* (9.1)	**-0.12*** (9.3)

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

Source : Own computation

Generally, we can say that most of the coefficients in the profit and input demand functions take the correct sign and are significant. The F test can also be used to test the overall significance of the variables. In model 1, the F(6,115) statistics for OLS and SURE results are 12.43 and 10.91 respectively. For model 2, the same statistics for the OLS and SURE results are 10.46 and 9.17 respectively. In both cases, we can reject the null hypothesis which says that the overall regression is not significant. The Durbin-Watson Statistics also reveals that there is no serious serial correlation problem. The homoscedasticity test based on the regression of squared residuals on squared fitted values also shows that there is no heteroscedasticity problem. Therefore, one can conclude that the estimated profit and input demand functions satisfy the statistical, econometrical and theoretical requirements and can be used for further analysis.

5.3.3 The Impact of Education on Allocative and Technical Efficiency of Farmers

So far we have tried to see the statistical and econometric properties of the estimated profit and input demand functions and their theoretical consistency. 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 and analyzed. The Wald test statistics has asymptotic chi-square distribution with the number of restrictions taken as degrees of freedom. The null hypothesis can't be rejected unless the computed chi-square value is greater than the tabulated value at the appropriate confidence interval [for the full derivation of the statistics see kalirajan, 1992]. Table 5.6 summarizes the results of the 22 restrictions based on models 1 and 2.

1. **Relative Allocative and Technical Efficiency:**

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. This also implies that educated and illiterate farmers have different profit functions. At the same time, since the coefficients of D^L are positive and significant in all the equations estimated (see tables 5.4 & 5.5), we can conclude that literate farmers are economically more efficient than illiterate farmers in the sub-sample 2.

However, the relatively high economic efficiency of educated farmers can arise from their higher technical, allocative, or economic efficiency than illiterate farmers. Therefore, we test hypothesis 2, concerning equal relative allocative and technical efficiency. As shown in Table 5.6., this hypothesis is rejected at less than 1 percent level in both models. These results suggest that the higher economic efficiency of educated farmers emanate from their superiority in both technical and allocative efficiency.

Hypothesis 3 also helps us to disentangle the components of economic efficiency. It tests whether literate farmers are allocatively more efficient in using hired labour and fertilizer inputs than illiterate farmers. This hypothesis is rejected in the case of Model 1. The results of hypotheses 3.1 and 3.2 in model 1 also reveal that the relatively high allocative efficiency of educated farmers hold even when we test the hypotheses for each inputs. This shows that HHs which have at least one person who can read and write are more successful in equating the MVP of hired labour and fertilizer inputs to their corresponding market prices than other HHs who don't have any member who can read or write.

The hypotheses of equal allocative efficiency (where inputs are tested in combination and separately) can't be, however, rejected in model 2 even at 10 percent level. In view of the

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

* The null hypothesis can be rejected at less than 1 percent ** The null hypothesis can be rejected at 5 percent
*** The null hypothesis can be rejected at 10 percent, Df.is Degrees of freedom

Source: Own computation

rejection of these hypotheses in model 1, this result suggests that for achieving relative allocative efficiency in utilization of hired labour and\ or fertilizer inputs, education more than the three Rs (reading, writing and primary numeracy) may not be required. The higher Wald statistics in model 1 than in model 2 for hypotheses 1 and 3 also support this argument. However, we can generally conclude that educated farmers are technically and allocativelly more efficient than illiterate farmers.

These results are consistent with our a priori expectations. In Ethiopia, where the prices of inputs and outputs were changed by 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 to 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, analyze 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 analyze the seasonal variations in input and output prices, the quantities and qualities of inputs to be used and outputs to be produced, and to synthesize other market and technical information.

2. **Absolute Allocative Efficiency:**

So far we have seen that educated farmers achieve higher technical and allocative efficiency than uneducated farmers. This does not, however, mean that educated farmers are absolutely allocative efficient. Farmers are absolute allocative efficient if they equate the MVP of an input to its price. Hypothesis 4 through 5.2 can be used to test which group of farmers are absolutely allocative efficient in utilization of the two variable inputs. Hypotheses 4, 4.1, 4.2, and 5.2 can not be rejected even at 20 percent level in both models. Hypotheses 5 and 5.1 are, however, rejected in both models at less than 1 percent level. These two different results reveal that the hypothesis of absolute allocational efficiency in utilization of both hired labour and fertilizer inputs simultaneously and labour input separately can not be rejected for educated farmers but not for illiterate ones. In other words, these results show that illiterate farmers fail to maximize profit by equating the marginal value product of hired labour and fertilizer inputs simultaneously and hired labour input separately 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.

The theoretical foundation for the above results is almost similar to the previous case. By increasing the ability of farmers to acquire, process and analyze different technical and market information,education helps farmers to chose the appropriate bundles of inputs and optimal levels of output. Thus it may not be surprising for educated farmers to be allocatively efficient.

However, surprisingly we can't reject hypothesis 5.2 in both models. These results imply that illiterate and literate farmers are equally successful in equating the MVP of fertilizer to its price. Put differently, these results reveal that fertilizer input is almost optimally used by both educated and illiterate farmers. A ready made theoretical justification may not be given for this result. Probably the usage of the recommended amount of fertilizer per hectare by most of the farmers and less variability in the price of fertilizer (the mean price of fertilizer was Birr 1.60 \ kg with 0.49 standard deviation) can be taken as possible reasons for this unexpected result.

We can also see the impact of education on efficiency by combining the results given in Appendix 4 and Table 5.3. The coefficients of the education variable are positive and significant in both tables. These imply that education increases not only the probability of farmers to use fertilizer and hired labour inputs but also the ability of farmers to adopt and to use these resources efficiently. This implies that education can be considered as a two edge sword. 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 chose profit maximizing or cost minimizing levels of inputs and outputs.

The policy implications of the above results are clear. Farmers uncovered with free information and rationality assumptions are likely to make technical and/or allocative errors. In other words the hypothesis that 'farmers are poor but efficient' does not hold for every farmer. 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.

5.4. THE IMPACT OF EDUCATION ON FARM SPECIFIC PROFIT EFFICIENCY

The previous Y-L type of profit functions do not give farm specific efficiency values. As a result they do not have room to analyze the impact of various farmers' attributes on efficiency. To over come these limitations of the Y-L type of profit functions and to determine farm specific profit efficiency values we use model 1 specified in section 5.2. We use the value of farm specific profit efficiency [PE] indices computed from

$$PE = E[\Pi_{2i}/ U_i,W_i,Z_i] \,/\, E[\Pi_{2i}/U_i=0,W_i,Z_i]$$

as the dependent variable and education, age, land, and soil fertility as explanatory variables. Since the profit efficiency variable is not normally distributed, it is transformed into normal by using the formula **TPE = ln [PE/(1-PE)]**, where TPE is the transformed profit efficiency. Then TPE is regressed on the above variables. Our a priori expectation is that profit efficiency is positively related to all the variables included in the model. The results are presented in Table 5.7.

Age,area cultivated and soil fertility variables take unexpected sign and they are insignificant. This implies that these variables do not have any significant impact on farm specific profit efficiency differentials. The education variables, however, are positive in all cases and statistically significant at 10 percent level in case of educated 2 (completion of primary education) variable. These imply that profit efficiency is positively related with education. In other words, HHs with 1 or more persons in the family who can read or write achieve higher profit efficiency than HHs without any member who can read or write. This result is in line with our a priori expectation and our previous results.

Table 5.7. OLS Results of Factors That Affect Farm Specific Profit Efficiency

Variable	Model 1* Coefficient	Model 2* Coefficient
Constant	0.3569 (0.372)	0.4577 (0.322)
Educated 1	0.2517 (0.220)	-
Educated 2	-	0.2566 (0.162)
Age of the HH head	-0.0047 (.0047)	-0.005 (.005)
Area cultivated	-0.1596 (0.142)	-0.1789 (0.141)
Soil fertility	-0.1419 (0.166)	-0.096 (0.169)

* Model 1 and 2 are based on educated 1 and educated 2 variables definition respectively definition (see section 4.2.2 for the details)

Note: Figures in Parenthesis are standard errors

Source: Own computation

5.5. THE IMPACT OF EDUCATION ON ADOPTION OF FERTILIZER INPUT UNDER DIFFERENT ENVIRONMENTS

Analyzing the impact of education on efficiency under different environments has several interesting implications. However, due to lack of data we are not able to compute efficiency indices for different PAs under different level of developments. As a result we limit our analysis on the impact of education on the adoption of fertilizer under different environments. Knowing the impact of education on adoption of new technologies such as chemical fertilizer is important mainly because it can significantly affect the nature of policy interventions in the rural areas. If education is more effective in relatively modern rural areas than in traditional ones, the implication is that the effectiveness of educational institutions in traditional areas is very low at least in encouraging farmers to use modern inputs. If the reverse situation holds, the implication will change. In relatively modern areas the role of education in acquainting and encouraging farmers to use modern technology is overwhelmed by other facilities such as greater access to mass media, markets, and by other non formal educational services. Therefore the emphasis of policy makers should be in expanding schools in relatively traditional areas.

The theory and the findings of different researchers is quite different. The frequently proposed hypothesis is that the impact of education on adoption of modern inputs and consequently on efficiency is higher under modern environment than under traditional ones. Lockheed et al., for instance concluded that:

> "Under modernizing conditions, the effects of education are substantially greater than under traditional conditions. Over all the studies, the mean increase in output for four years of education under traditional conditions was 1.3 percent compared with 9.5 percent under modernizing conditions" [Lockheed et al.,1980, P.134].

The counter argument emphasises that the impact of education is high in traditional areas where production is bounded with backward cultural practices and where breaking of traditional thinking and state of arts is very essential for disseminating of modern thinking. According to this line of argument, education may have insignificant effects in modern areas since farmers have various alternatives of learning, acquiring and using modern technologies. Kalirajan and Shand argued that:

> "Survey evidence showed that most of the participants learned about the technology ... from mass media such as radio and news papers. Thus, mass media played an important role in providing information about the technology to farmers in the study area" [Kalirajan and Shand, 1984, P.238]

This is almost similar to the findings of many researchers on returns to education which conclude that the average rate of return to education is much higher in developing countries than in developed ones.

In order to analyze the impact of education on adoption of fertilizer under different environments, fifteen PAs widespread all over the country (see Map 1) and 1474 HHs were used. The descriptive statistics of the variables used are presented in Table 5.8. The 15 PAs are divided into modern and traditional environments on the basis of the method discussed in section 4.1.1. Then one is given for modern PAs and 0 otherwise. This way of coding the environment variable helps us to analyze the impact of education on the adoption of fertilizer input under different environments. Table 5.9 provides the result of the binomial probit model.

A priorily it is hypothesized that in both models land ownership, age, environment, and education increase the probability of adoption of new technologies such as fertilizer. We can't, however, a priorily hypothesize the sign of the coefficient of the interaction variable.

Table 5.8. Descriptive Statistics of Selected Variables

Name of the PA	Environment	% of HHs used fertilizer	% of HHs who have at least one person	
			RWALPC	CPE
Adado	modern	0	59.4	33.1
Aze Deboa	modern	40.0	92.0	60.0
Do'oma	traditional	2.7	74.0	41.1
Gara Goda	traditional	89.5	60.0	34.7
Debre Birhan	modern	82.5	62.0	47.0
Dinki	traditional	9.2	49.4	4.5
Shumsha	traditional	0.6	52.1	26.7
Yetmen	modern	9.8	72.1	16.4
Adele Keke	modern	40.0	37.1	7.2
Korodegaga	traditional	51.8	58.3	47.2
Sirbana Godeti	modern	32.0	75.3	44.8
Trufa kecheme	modern	16.5	90.3	56.3
Geblen	traditional	3.0	41.0	25.7
Harresaw	traditional	9.2	41.0	28.9

RWALPC = Read, Write and Adult Literacy Program Certificat [ALPC]
CPE = Completed primary education
Source: Computed from the 1993 Ethiopian Rural HH survey

All the coefficients have the hypothesized signs except the age variable which picks the wrong sign though insignificant. The positive and significant values of land ownership variable indicate that the rate of adoption of fertilizer and cultivating one's own land have positive association. At the same time the positive and significant values of the coefficients of the education variables in both models suggest that the probability of adoption of fertilizer increases as the education of farmers increases. The environment variables are positive and statistically significant in both cases. This is in line with our a priori expectation. It implies that the probability of adopting fertilizer declines as one moves far from Addis Ababa and far from major social and economic services.

The coefficients of the interaction variables of education and environment take negative sign in both cases. These results coupled with the positive and significant coefficients of the education and the environment variables individually, imply that education and environment variables are substitutes in modern environments and complementary in traditional ones. In other words the overall impact of education on the probability of adoption of fertilizer in modern environment is -0.005 (0.377 -0.382) in the case of educated 1 and 0.125 (0.349-0.224) in the case of primary education completion. The same figures for traditional environments are, however, 0.759 (0.377+0.382) and 0.573 (0.349+ 0.224). The implication is that the role of education in increasing the probability of farmers to adopt fertilizer is low in modern environments and high in traditional areas. This suggests that the advantage of education in encouraging farmers to adopt fertilizer is eroded by modern environment.

As suggested earlier farmers in modern environment can learn about fertilizer and other inputs from other various sources outside the school system via radio, news papers, markets, etc. On the other hand, in traditional areas, where the above medias hardly reach the farmers,

Table 5.9. MLE Results of the Binomial Probit Model

Variables	Coefficients	
Constant	-2.665* (14.2)	-2.554* (15.0)
Soil fertility	0.345* (4.0)	0.348* (4.1)
landownership	1.173* (12.8)	1.172* (12.8)
Educated 1	0.377* (2.6)	-
Educated 2	-	0.349* (2.4)
Age of the HH head	-0.0001 (0.04)	-0.0001 (0.2)
Environment modern	1.590* (10.5)	1.440* (12.7)
Modern environment *educated 1	-0.382* (2.2)	-
Modern environment * educated 2	-	-0.2236 (1.3)

* Significant at 1 percent

Note : Figures in parentheses are t ratios
Source : Own computation

the only feasible source of information are schools and sometimes agricultural offices. Therefore, in relatively modern areas formal education may not be a significant factor in stimulating farmers to adopt fertilizer input. In traditional environments, however, farmers need to have certain knowledge and to put special effort to collect and analyze information about fertilizer and to decide whether to adopt it or not. To put it differently, in traditional areas farmers need to have a certain critical level of education in order to adopt new innovations such as fertilizer compared to farmers in modern areas. Thus, education and traditional environment are complementary in traditional PAs and substitute in modern PAs. This finding is in contrary to Lockheed's, et al., and in conformity with Kalirajan and Shand's assertions.

The policy implications of these results are clear. From the point of increasing the probability of farmers to adopt new variables such as fertilizer, the emphasis of policy makers should be on expanding schools and on increasing school participation rates in relatively traditional areas.

CHAPTER SIX

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 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 with out introducing modern inputs and thereby 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 expansiveness this policy option did not achieve the desired results.

The empirical results of this study do not also support the 'efficient but poor' hypothesis. It was found 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 inputs, 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 122 farmers show that the hypothesis of equal economic efficiency between literate and illiterate farmers is rejected. This reveals 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 farmers.

The frontier profit function which takes into account farm specific profit efficiency also supports the above conclusion. The result suggests that there is a wide variation in profit efficiency across farms. Various socio-economic variables are used to explain these profit efficiency differentials and it is found that education is positively and significantly related to profit efficiency. This implies that a HH who has at least one permanent member who can read or write achieves higher profit efficiency than a family that does not have at least one literate member.

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 only 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 should be neglected. The conclusion of the study 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 via education by helping illiterate farmers to achieve the efficiency level achieved by their relatively educated neighbors.

Introducing new varieties of inputs and modern technologies alone may not also improve the efficiency of farmers since there might be great difficulty on the part of the unexperienced and uneducated farmers to understand, accept and properly utilize new innovations. The result of this study also supports this argument. It is found that education increases not only the efficiency of farmers through better utilization of the existing resources and reducing allocative errors but also by increasing the probability of farmers to adopt new technologies such as fertilizer. This suggests that farmers need either long experience from their neighbors or a minimum critical level of education to collect, organize, and analyze information, concerning new inputs and then to decide whether to adopt them or not.

An attempt was also made to identify the impact of education on adoption of fertilizer under different environments. Living in a modern environment is found to have a positive and significant impact on increasing the probability of farmers to adopt fertilizer. It implies that the probability of farmers to adopt new technology declines as one moves far away from major urban centers and social and economic infrastructural facilities.

The interactions between education and environment have also shown interesting results. The coefficient of this variable is negative in modern environments. This reveals that the role of education in increasing the probability of farmers to adopt new technologies is substituted or eroded by other facilities such as mass media, traders etc., in modern environments.

In traditional areas, however, where these facilities hardly reach the farmers, the role of education in encouraging farmers to adopt new innovations such as fertilizer is very critical. In other words, in traditional areas where the importance, method of application and even the existence of modern inputs such as fertilizer is not well known, adoption of new inputs requires considerable amount of efforts. Education by increasing the ability of farmers to collect and synthesize various information and by giving the courage to break the traditional 'crust of custom', helps farmers to adopt new innovations such as fertilizer even in unfavorable environments such as in remote areas where almost every modern thing is inaccessible.

This result suggests that policy makers might fruitfully place much emphasis on expanding elementary schools and increasing the enrolment rates in relatively backward areas at least to increase the probability of farmers to adopt fertilizer input. In other words the expansion of education in traditional areas is economically more important and has high pay off than in modern areas since it is usually the only means to break the traditional state of arts and thinking in backward areas.

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APPENDICES

Appendix 1. Variables Used to Classify the PAs as Modern or Traditional

Appendix 1.1 Distance and Road Accessibility

No PA*	Name of the PA	DAA in Km		DWT in Km		RA	
		AV	VD	AV	VD	AV	VD
01	Adado	386	0	10	1	AWR	1
02	Aze Deboa	359	1	4	1	AWR	1
03	Do'oma	492	0	2	1	DWR	1
04	Gara Goda	375	1	11	1	AWR	1
06	Debre Brhan	110	1	10	1	AWR	1
07	Dinki	153	1	25	0	NR	0
08	Shumsha	630	0	12	1	DWR	1
09	Yetmen	250	1	15	0	AWR	1
10	Adele Keke	510	0	15	0	AWR	1
11	Korodegaga	128	1	25	0	NR	0
12	Sirbana Godeti	57	1	10	1	AWR	1
13	Trufe Kechema	50	1	12.5	1	AWR	1
14	Geblen	898	0	22	0	DWR	1
15	Harresaw	869	0	17	0	AWR	1
AVE		376.2		12.6			

DAA= Distance from A.A.; DWT= Distance from the woreda town

RA= Road accessibility; AWR = All weather road, DWR = Dry weather road; NR = No road; AV =Actual Value ; VD = Dummy Value; AVE= Average value for the total PAs

Source: Own computation

Appendix 1.2 Social Services [Health and Education]

No PA	In the PA No. of				DNHS/H in km	
	Elementary school		Clinic		AV	VD
	AV	VD	AV	DV		
01	1	1	1	1	25	1
02	1	1	0	0	70	0
03	1	1	0	0	102	0
04	1	1	1	1	43	0
06	1	1	1	1	10	1
07	0	0	0	0	66	0
08	1	1	0	0	110	0
09	1	1	1	1	15	1
10	1	1	1	1	27	1
11	1	1	0	0	30	1
12	0	0	0	0	2	1
13	1	1	0	0	10	1
14	0	0	0	0	25	1
15	1	1	1	1	40	1
AVE	0.75		0.43		41.1	

DNHS/H = Distance of the PA from the nearest high school or hospital in km

Source : Own computation

Appendix 1.3. Housing and Other Services

No.PA	PTRH		NR		NS		DNM		TVD	Decision
	AV	VD	AV	VD	AV	VD	AV	VD		
01	6	0	5	0	1	0	0	1	6	**MODE**
02	10	0	0	0	0	0	4	1	5	**MODE**
03	7	0	2	0	0	0	0	1	4	**TRAD**
04	1	0	1	0	0	0	2	1	4	**TRAD**
06	25	1	32	1	0	0	10	0	8	**MODE**
07	0	0	3	0	0	0	8	0	1	**TRAD**
08	0	0	1	0	0	0	12	0	1	**TRAD**
09	90	1	2	0	10	1	0	1	8	**MODE**
10	75	1	6	0	8	1	0	1	7	**MODE**
11	30	1	5	0	1	1	8	0	4	**TRAD**
12	55	1	14	1	5	0	2	1	8	**MODE**
13	1	0	18	1	4	1	6	1	8	**MODE**
14	0	0	1	0	0	0	20	0	1	**TRAD**
15	0	0	3	0	0	0	18	0	3	**TRAD**
AVE	21.5		6.6		2.1		6.4		4.8	

PTRH = Percentage of tin roofed houses; NR = Number of radios ; NS = Number of shops; ; DNM = Distance to the nearest market ; TVD = Total value of Dummies ; MODE = Modern environment ; TRAD = Traditional environment.

Source : Own computation

Appendix 2 The Bowley's and the Pseudo Test Results for Selected Variables.

variable	b_s		S_p		stand.deva	
	raw	trans	raw	trans	raw	trans
value of output	0.33	0.13	1457.0	0.61	1970.0	0.64
family and traditional labour	0.40	-0.04	199.81	1.53	272.5	1.63
fertilizer in kg	0.33	0.00	111.10	1.03	101.9	0.77
cost of fertilizer	0.12	-0.05	135.55	1.52	134.7	0.70
asset	0.43	1.52	320.47	-0.05	880.4	1.45
profit	0.37	0.17	332.0	0.64	1790.	0.71
wage	0.16	-0.04	3.00	0.63	4.35	0.65
land	0.08	-0.05	0.85	0.40	14.58	0.47
price of fertilizer in kg.	-0.15	-0.18	0.29	0.10	0.49	0.18

raw = the original data, trans = log of the variable.

Source: Own computation

Appendix 3 Correlation Coefficients of the Error Terms of the Profit and the Input Demand Functions

	V	E_1	E_2
V	1.0000	0.3656	0.5364
E_1	0.3656	1.0000	0.4049
E_2	0.5364	0.4049	1.0000

Source: Own computation

Appendix 4 Probit Analysis: Determinants of Fertilizer and Hired Labour Inputs Usage

Variable	Coefficient	ML Estimated Values
1. land ownership	β_1	0.3981* (2.535)
2. soil fertility	β_2	0.6333* (4.084)
3. area cultivated	β_3	0.0089* (1.014)
4. asset	β_4	0.0003* (2.557)
5. age	β_5	(-0.0009) (0.1941)
6. education	β_6	0.54721* (3.383)
7. constant	αo	-1.0726* (3.903)
log likelihood function Restricted log likelihood		-186.4687 -212.1693
$PseudoR^2=1-\frac{loglike}{restricted}$		.40127

* Significant at 1%

Note : Figure in parentheses are t ratios

Source: Own computation

DECLARATION

I, the undersigned, declare that this thesis is my own original work and has not been presented in any University. All sources of materials for this thesis have been fully acknowledged.

Name : Abay Asfaw Gethanun

Signature : ....

Date : 26th May, 1997.

Place : Addis Ababa.