FARMER'S HEALTH AND AGRICULTURAL PRODUCTIVITY IN RURAL ETHIOPIA

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ABSTRACT

This thesis assesses the impact of farm household's health on agricultural productivity in Ethiopia. Two years panel data (2004 and 2009) from Ethiopian longitudinal rural household survey (ERHS) are used. First, Cobb Douglas (CD) stochastic frontier analysis is applied to explain the relationship between farm output and inputs. The results indicate most of the major inputs considered such as labour, land soil and fertility influence agriculture production significantly and positively. My major variable of interest, illness is negatively and statistically correlated with agricultural production as expected. Second, technical efficiency score is derived from the CD stochastic frontier estimation model. The results reveal that households exposed to illness have on average 33.5% technical efficiency score, whilst the households not exposed to illness score 48.9%. Thus, this study implies the importance of the quality of the health system to bring about changes in the agricultural production. This is of major interest especially since the Ethiopian economy is mainly agrarian and any factor contributing towards efficiency gains in the sector are of paramount importance.

PREFACE

I would like to acknowledge the Norwegian university of life science (UMB) and School of Economics and Business for facilitating the programme for the international students. I would like to forward my gratitude to all instructors that taught me during my studies in the university. I sincerely thank my advisor Eirik Romstad for his invaluable comments and recommendation in shaping the structure of the thesis. I also would like to acknowledge the International Food Policy Research Institute (IFPRI) for making the Ethiopian rural household survey (ERHS) data available.

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Meseret Urgecha

TABLE OF CONTENTS

List of Figures

List of Tables

CHAPTER ONE: INTRODUCTION

1.1 Background

Ethiopia is the second most populated country in Africa with 82.8 million people, and ranks fourteenth in the world. Agriculture is the mainstay of its economy. It supports 50% of the country's GDP, provides employment for about 85% of the population, generates 90% of the foreign earnings and provides 70% of raw materials for industry. The major export items are mainly from the agricultural sector including, coffee, hides and skins (leather products), pulses, oilseeds, beeswax, flowers and minerals like gold and, horticulture, meat, cotton, and clothing. Agriculture, thus determines the pace and direction of overall economic growth for the country. This has been recognized by the government's current economic policy, the Agriculture Development Led Industrialization (ADLI) since 1993. ADLI aims at strengthening the linkage between agriculture and the industrial sector mainly through enhancing the productivity of small scale framers, expanding large scale commercial farms and restructuring the manufacturing sector. Despite several efforts, persistent poverty, poor nutritional status, low education levels and poor access to health services are some of the predicaments of the Ethiopian economy.

Agriculture in the country has largely remained small scale with subsistence farmers who have small or no marketable surplus. Small scale farming accounts about 90% of the cropped land and agricultural output, which is characterized by low-input and low-output production system with heavy dependence on nature (Devereux, 2000; von Braun et al., 1998). About 87% of rural households operate less than 2 hectares, 64.5 % of them cultivated farms less than one hectare, while 40.6 % operated land sizes of 0.5 hectare and less in the 2000 cropping season (CSA, 2003; Negatu, 2005). Small holder farmers belong to the poorest segment of the population. This makes them vulnerable to food insecurity and low level of productivity which increase the variation between the demand and supply of food (Askal, 2010).

Good heath essentially affects the production of farmers in the agriculture sub-sector. Health enhances work effectiveness and the productivity of an individual by increasing the physical and mental capacity of people (Ulimwengu, 2009). Healthier and better nourished people are more likely to be more productive than unhealthy people (Appleton, 2002). According to Corinna and Ruel (2006), agriculture and health affect each other, i.e., that agriculture influences health and health influences agriculture. Furthermore, they state that prevalence of under nutrition, over nutrition and disease affect the demand for food quality, quantity, diversity and price, which in turn are major factors affecting agricultural productivity. Poor health brings loss of labour hours, loss of money and it may cause death to the household. All these factors make it more difficult for the households to innovate and improve their living standards.

My thesis studies the effects of health situation on agricultural production and efficiency of smallholder farmers in the major regions of Ethiopia, Tigiray, Oromia, Amhara and Southern Nations and Nationalities People (SNNP). Thus, my study measures and identifies factors that affect agricultural production and quantifies the net impact of health on agricultural production efficiency and finally, draws conclusions and relevant policy implications.

1.2 Statement of the problem

Food insecurity has the major problem in Ethiopia. Inefficiency can be one of the major causes of food insecurity. Agriculture is a basic source of income and a way of life in rural areas. A majority of the land holders in the agricultural sectors are small households several studies have found that smaller farms are more efficient than larger farmers (Sridhar, 2007; Okon et al, 2010; Mkhabela, 2005). As Schultz (1964), hypothesized the small farms in developing countries are too poor but efficient in the ways they allocate their resources. Since developing countries are characterized by excessive labour supply and fragmented land holding, this hypothesis may not hold. There is wide efficiency variation among different households based on standard of living. Households with low economic status might have low efficiency score.

Production efficiency is affected by different factors based on stages of development of the country. The agricultural sector in developing countries is characterized by poor cultivation practices, rain-fed or poor irrigation systems. Inefficient utilization of the agricultural inputs, persistence of subsistence production, and lack of improved technology, soil degradation, deforestation, high population and poor health condition are other factors that stagnated agriculture in these countries.

There are also many factors like household characteristic, farm quality, farm size and institutional factors that affect agricultural production in Ethiopia. Illness is one of the major problems that hamper the production of agriculture. A mere observation can show that due to poor infrastructure and insufficient health access in most of the rural areas people should travel long distances in order to get a medical care. Besides, the existing services within health institutions are not up to the standard. In the situation where there is poor health, there will be loss of labour hours that lead to low level of productivity in the agricultural production.

Considering the fact that illness has significant effect on agricultural production and productivity of the small households, it is imperative to analyse the relationship between health and agricultural production. And thus, this thesis tries to address what input variables affect the agricultural production taking health variable into account. Further, it analyses the impact of illness on production efficiency of the smallholder farmer.

1.3 Objectives of the thesis

This thesis analyses the effect of health on agricultural production and compares the effect of health on production efficiency of the smallholder farmers in Ethiopia. To shed a light on these issues, I used Ethiopian rural household's survey data, collected from four main regions: Tigray, Oromia, Amhara and SNNP covering 22 peasant association, and 1121 and 1270 households in 2004 and 2009 respectively. Cobb-Douglas production function is used to assess the effect of health on agricultural production. And subsequently, Stochastic Frontier Analysis (SFA) method is used to assess farmers' efficiency.

In general, the main motive of this paper is to measure the net impact of health on the agricultural production and efficiency of householder farmers in Ethiopia. The specific objectives of the thesis are:

i) To estimate effect of health on agricultural production, and

ii) To compare the effect of health on production efficiency.

1.4 Structure of the thesis

The thesis is organized into five chapters. This first chapter deals with the background, statement of the problem and objectives of the study. The second chapter reviews different studies regarding the relationships between agricultural production and health. In chapter three, I discuss the study area and methodology of the study. Chapter four presents the results of the study, while chapter five concludes and provides policy implications.

CHAPTER TWO: LITERATURE REVIEW

The relationship between good health and economic wealth is well documented. The impact of health can be manifested as increased income, wages, efficiency, and productivity. And hence, this relationship can readily be seen in descriptive statistics in order to disentangle the precise nature of the connection. It is likely that causality runs in both directions. However, both health and prosperity (increase in efficiency and/or productivity) are also affected by many other variables. This makes the analysis more complicated.

As mentioned in the introductory chapter the causality between health and agricultural productivity is bidirectional. Health affects agricultural productivity and hence lower income which can be spent to improve health. When there is health shock, the supply of labour is affected negatively due to the loss of work-days spent on the farm that in turn adversely affects the efficiency of the labour and decreases the productivity of agriculture. Health shock also decreases off-farm income of the farmer that also negatively impacts agricultural productivity. Health may affect the allocation of time that an individual use for the production activities and it may also relate the marginal utility of the households that affect their consumption or leisure decisions (Adhvaryuy and Nyshadhamz, 2010). However, this may not be the case where perfect market prevails and hired labour perfectly substitute family labour.

Different empirical findings explain the relationship between agricultural productivity and health. Many studies find that health has a significant effect on the agricultural productivity of the households (Adhvaryuy and Nyshadhamz, 2010; Egbetokun et.al, 2012; Ajani and Ugwu, 2008; Ulimwengu, 2009; Maumbe and Swinton, 2003; Loureiro, 2008).

The health problem has direct and indirect cost on the productivity of the farmer. The adverse health impacts on the outcomes by affecting the capacity of the labour. Egbetokun et.al (2012) assess the impact of health on agricultural technical efficiency in Nigeria. They selected 120 farm households in multi-stage random sampling technique and carried out the maximum likelihood stochastic frontier analysis. They found that one percent improvement in the health condition of the farmers will increase efficiency by 21 percent. Similarly, in Kainji lake Basin of North central Nigeria Ajani and Ugwu (2008) studied adverse health impacts on the productivity of agriculture and used SFA technique. They found the technical efficiency of the farmer falls between the range 0.29-0.99 and mean 0.85. This implies that in the short run the farmers' efficiency can improve by 15% with the available technology. The health variable which is measured in days lost during sickness is statistically significant. They got efficiency value of 0.31 which implies that one present improvement in the farmers' health conditions led to 31% increase in the efficiency of the farmer. Furthermore, Ulimwengu (2009) studied the impact of farmers' health status on both agricultural efficiency and poverty reduction using a stochastic frontier analysis. He found that due to the sickness of the household member on critical period of farming activity, on average led to a loss of 33 person-days of farming activity per year and 17.8% of output loss. On the other hand, Antle and Pingali (1994) combined production data from farm-level survey and health data from the same population of farmers in two rice-producing regions of the Philippines. As a result they found that pesticide use had a negative effect on farmer health, whereas farmer health had a significant positive effect on productivity. The improvement in the farmers' health increase productivity and it brings better innovation power to the farmer. Loureiro (2008) assesses the effect of farmers' health status on agricultural productivity of Norway by using SFA. He found that the farmer's health status was statistically significant in explaining the variance of the inefficiency component in the Norwegian agricultural sector. Croppenstedt and Muller (2000) find that there is significant link between health and nutritional status and agricultural productivity. The result shows that distance to water, nutritional and morbidity statues significantly affect the agricultural productivity.

Empirical evidence reveals that agricultural households are more likely to be affected by the sickness than non-agricultural households (Ulimwengu, 2009). This might be the reason that the households that engaged in agriculture are poor. The land distributions of the poor households are very limited when compared to the richer households. In Pakistan the production elasticity of land of rich farmers is higher than the poor farmer (Ahmad, 2003). Agriculture system might be exposed to different health problems, including exposure to different pesticides, insecticides and disease such as, Malaria, HIV, TB, parasitic infections, etc. (Kim et. al., 1997; Giradin et.al., 2004; and Fox et. al., 2004). Kim et al. (1997) studied the impact of onchocercal skin disease on economic productivity of the labour force on coffee plantation in southern west Ethiopia. They use the sample of 425 plantation workers and estimate the daily wage equation for wage employee. As a result permanent male employee bears significant losses in economic productivity.

CHAPTER THREE: DATA SOURCE AND METHODS

3.1 Data Source

Ethiopian longitudinal rural household survey (ERHS) data is used to analyze the health-efficiency linkages. The data was collected by the Economics Department of Addis Ababa University (AAU), the Centre for the Study of African Economies (CSAE), University of Oxford, and the International Food Policy Research Institute (IFPRI). It is a panel household data that covers households in a number of villages in rural Ethiopia. Within each village random sampling was used. In this thesis, I use the six and seventh round data from the years 2004 and 2009, respectively. It comprises four main regions of the country; Amhara, Tigray, Oromya and SNNP (see Figure 1 for the maps of the survey area). It covers 20 and 22 peasant associations (PAs) with a total of 1121 and 1270 samples, in the years 2004 and 2009, respectively.

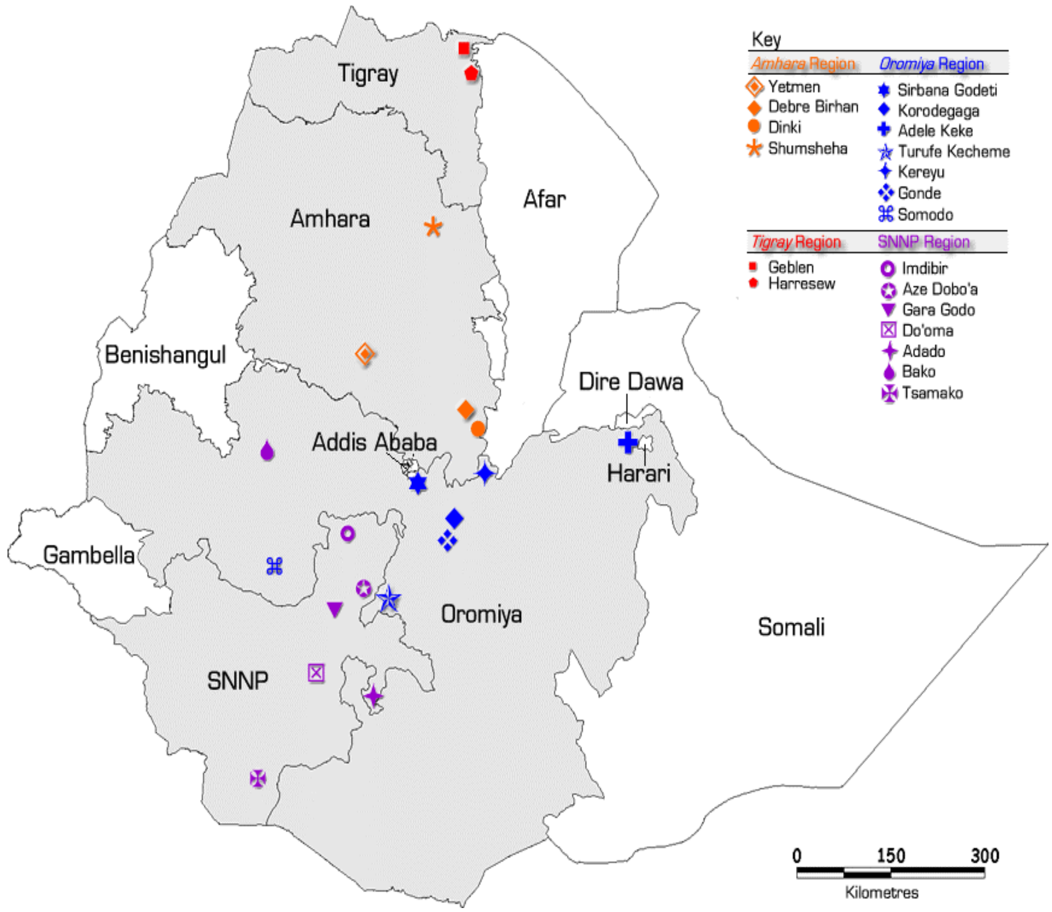

Figure 1. Map of the survey areas

3.2 Research methodology

The analysis is based on an economic efficiency technique that measures the agricultural productivity of households. That is economic efficiency measures the ability of individuals, firms or households to utilize and allocate available resources and technology in most possible competent and productive way. There are four sources of economic efficiency: technical, allocative, scale and scope efficiency. Technical efficiency will be attained when households or firms produce the maximum possible output from a bundle of given inputs or farm households minimize the inputs to produce the given level of output. Allocative efficiency holds when the households or firms maximize profit by minimizing cost and maximizing revenue given market prices. On the other hand, household or firm attains scale efficiency when any other firms or households cannot produce more output and get more profit given input and technology. Scope efficiency achieves when firm or household produces optimal mix of outputs (Chavas et al, 2005; Alpizar, 2007).

This thesis uses technical efficiency methods. There are two ways for measuring technical efficiency: the output oriented approach, and the input oriented approach. The main purpose of output oriented approach is to identify factors that help in increasing output from the given input and the technology, whilst the main purpose of input oriented approach is to indicate how households can minimize the input cost to produce the same output (Gebreegziabher, et al., 2004). Thus, since the main concern of rural households in developing countries is to maximize output than minimize input cost, this thesis uses the output oriented approach.

Further, one can also measure agricultural production efficiency either through parametric or non parametric approaches. Parametric approaches generally impose parametric restrictions on production function specification and estimation, whilst non-parametric estimation does not impose any parametric restriction on production function, technology and inputs (Alpizar, 2007).

This thesis follows the parametric stochastic frontier analysis (SFA) to estimate the production efficiency. The degree of inefficiencies is determined by the deviation from the frontier (Schmidt, et.al.1987). Below is the description of the parametric stochastic frontier method applied in this study.

The stochastic production frontier for farmer *i* at period *t* is given by equation (1) below.

$$Y_{it} = f(X_{it}, \beta) * \exp(V_{it} - U_{it}) \qquad (1)$$

where *i* ε (1, 2, ..., I) is an index for farm household i and t ε (1,2,...,T) represents time period *t*; Y_{it} is output of farmer *i* at time period *t*; $\boldsymbol{X}_{it}$ is a vector of inputs of farmer, **β** is a vector of unknown parameters to be estimated; V_{it} and U_{it} are the idiosyncratic and inefficiency components of the composed error term of farmer respectively.

The decomposition of the residual random variable, E_{it} into V_{it} and U_{it}, in the production function defines the stochastic production frontier function, as first proposed by Aigner, Love and Schmidt (1977) and Meeusen and van den Broeck (1977). Inefficiency is assumed to take zero or positive values. Those producers that have positive values lie below the efficiency frontier, while those that have zero values are efficient farmers that lie on the efficiency frontier. Component of the error term measures the departure of each producer from an efficiency frontier. Three assumptions are made:

i) V_{it} are identically and independently normally distributed with mean zero and standard deviation σ_v^2 i.e $V_{it} \sim N(0, \sigma_v^2)$

ii) U_{it} are independently distributed non-negative truncation of a normally distributed random variable with mean, $Z_{it}\delta$ and standard deviation, σ_u^2, where Z_{it} is a vector of household and region specific variables that affect efficiency, while δ is a vector of unknown parameters of the inefficiency equation.

iii) V_{it} and U_{it} are distributed independently of each other and are independently distributed of the X_{it}.

Given the stochastic production frontier equation, the level of technical efficiency (TE_{it}) of each farm household i at period t is:

$$TE_{it} = \frac{Y_{it}}{f(X_{it}, \beta) * \exp(V_{it})}$$

$$TE_{it} = \exp(-U_{it}) \qquad (2)$$

Since U_{it} are a non-negative truncation of normally distributed random variable, TE_{it} can take a maximum value of one. The specification allows for efficiency to vary over time. This definition of technical efficiency follows from the idea that if a farm household's actual production level, Y_{it}, is less than the maximum achievable production level, $f(X_{it}, \beta) * \exp(V_{it})$ that admits the existence of only idiosyncratic differences, and assuming no measurement error, then there is some inefficiency on the part of the farmer. And this inefficiency is greater, the lower Y_{it} is from $f(X_{it}, \beta) * \exp(V_{it})$, or the higher is U_{it}. Note that the inefficiency effects, U_{it}, as well as the symmetric error terms, V_{it}, may carry the effects of errors of measurement in both the explanatory as well as the dependent variables, just as any other econometric model.

Technical inefficiency is assumed to be a function of farm household and region specific variables, Z_{it} , and a set of parameter values, δ, to be estimated along with the production function parameters. The inefficiency equation is given by equation (3):

$$U_{it} = Z_{it}\delta + W_{it} \tag{3}$$

where W_{it} is a random variable that is assumed to be distributed with mean zero and variance σ_w^2. U_{it} is defined by the truncation of the normal distribution with the point of truncation given by - $Z_{it}\delta$. This is because $U_{it}=Z_{it}\delta + W_{it} \geq 0$, $W_{it} \geq -Z_{it}\delta$, so that W_{it} is truncated from below. U_{it} is assumed to be positive half normally distributed variable with mean zero and standard deviation, σ_u^2. That is U_{it} ~N (0, σ_u^2). The truncated normal distribution for U_{it} is given by:

$$g_{u(V_{it})} = \frac{1}{\sqrt{2\pi}\Phi(Z_{it}\, \sigma/\sigma_u)} \exp\left\{-\frac{(U_{it} - z_{it}\sigma)^2}{2\sigma_u^2}\right\}, \ U_{it} >= 0 \tag{4}$$

where $\Phi(.)$ is the standard normal cumulative distribution. Thus, f (U_{it}) is the density function of a normally distributed random variable with mean $Z_{it}\sigma$ truncated below at zero. The density functions of the random variable V_{it} given by equation (5):

$$g_{v(V_{it})} = \frac{1}{\sqrt{2\pi}\sigma_v} \exp\left\{-\frac{(V_{it})^2}{2\sigma_v^2}\right\}, \ V_{it} \ \varepsilon \ (-\infty, \infty) \tag{5}$$

Given that V_{it} and U_{it} are assumed to be distributed independently and omitting subscripts, their joint distribution is given by equation (6):

$$g_{uv(u,v)} = \frac{1}{\sqrt{2\pi}\sigma_v\sigma_u\Phi(Z\sigma/\sigma_u)}\exp\left\{-\frac{(U-Z\sigma)^2}{2\sigma_u^2}-\frac{v^2}{2\sigma_v^2}\right\}, \text{ U}\geq 0 \qquad (6)$$

Following the composite error term as $\varepsilon_{it} = V_{it} - U_{it} = Y_{it} - f(X_{it},\beta)$. The joint distribution of ε_{it} and U_{it} is given by equation (7):

$$f(U,\varepsilon) = \frac{1}{\sqrt{2\pi}\sigma_v\sigma_u\Phi(Z\sigma/\sigma_u)}\exp\left\{-\frac{(U-Z\sigma)^2}{2\sigma_u^2}-\frac{(U+\varepsilon)^2}{2\sigma_v^2}\right\} \qquad (7)$$

The marginal density function of ε is given as equation (8):

$$g_E(\varepsilon) = \int_0^\infty f(U,\varepsilon)dU$$

$$g_E(\varepsilon) = \frac{1}{\sqrt{2\pi}\left(\sigma_v^2+\sigma_u^2\right)^{1/2}\left[\Phi(Z\sigma/\sigma_u)\Big/\Phi(\mu^*/\sigma^*)\right]}\exp\left\{-\frac{(U+\varepsilon)^2}{2\left(\sigma_v^2+\sigma_u^2\right)}\right\} \qquad (8)$$

where $\mu^* = ()\left(\sigma_v^2 Z\sigma - \mu_u^2\varepsilon\right)/\left(\sigma_v^2+\sigma_u^2\right)$.

Accordingly, the density function of Y_{it} is given by equation (9):

$$g_y(Y_{it}) = \frac{1}{\sqrt{2\pi}(\sigma_u^2+\sigma_v^2)^{1/2}\left[\Phi(\mu_{it}^{\sim})/\Phi(\mu_{it}^{\sim *})\right]}\exp\left\{\frac{(Y_{it}-f(X_{it},\beta)+Z_{it}\delta)^2}{2(\sigma_u{}^2+\sigma_v^2)}\right\} \qquad (9)$$

where $\mu_{it}^{\sim} = Z_{it}\,\delta/\delta_u, \mu_{it}^{\sim *} = \mu_{it}^{*}/\sigma^{*}\ and \mu_{it}^{*} = \left[\mu_v^2 Z_{it\sigma} - \sigma_u^2 (Y_{it} - f(X_{it}, \beta))\right]/\sigma_v^2 + \sigma_u^2$.

Given the above equations and expressions, we have observations for t ε (1,2,...,T) and i ϵ (1,2,..., I) the log likelihood equation is given by equation (10):

$$L(\Theta, Y) = -\frac{1}{2}\left\{\left[\sum_{i=1}\ \sum_{t=1} \ln 2\pi + \ln\sigma^2\right] + \left[\sum_{i=1}^{I}\ \sum_{t=1}^{T}(Y_{it} - f(X_{it}, B) + Z_{it}\sigma)/\sigma^2\right] + \left[\ln\Phi(\mu_{it}^{\sim}) - \ln(\mu_{it}^{\sim *})\right]\right\} \quad (10)$$

where Θ`= (β', δ', σ_v^2, σ_u^2) is the parameter set. First order derivatives of the last equation with respect to the parameters sets provided.

Empirical model:

Cobb-Douglas production function specification is used to estimate the stochastic production frontier for this study.

$$\ln Y_{it} = \beta_0 + \beta_1\, Area_{it} + \beta_2\, \text{LabourEq} + \beta_3\, \text{Age}_{it} + \beta_4\, FertUse_{it} + \beta_5\, TLU_{it} + \beta_6\, Av\ land\ quality_{it} + \ldots + \beta_{ij} 2009 dummy_i + V_{it} - U_{it} \quad (11)$$

where $t \in (1, 6)$ is the period for which data are available in 2004 and 2009; and where $i \in ((1, 2, 3, \ldots 1477)$ represents farmer i. β_j are coefficients of the production function to be estimated. $\ln Y_{it}$ is the logarithm of real value of output of household i in period t.

The inefficiency equation:

Taking household specific variables, the inefficiency equation (U_{it}) is given by equation (12):

$$U_{it} = \delta_0 + \delta_1 \text{Sex}_{it} + \delta_2\, \text{Age}_{it} + \delta 3 \text{Educ}_{it} + \delta 4\, \text{Labour}_{it} + \delta_5\, TLU_{it} + \delta_6\, soil\_fer_{it} + \ldots + W_{it} \quad (12)$$

3.3 Description of the variables

Table 3.1 presents the description of the variables used in the analysis.

Table 3.1 Description of the variables

Sex	Sex of the households, as a dummy variable having a value of 1if male , 0 otherwise
Age	Age of the households
Educ	Education of the household head in years
Labour	Adult equivalent unit, the family labour available in the household.
Land	Total cultivated land
soil_fer	Soil fertility: 3 if the soil is bad, 2 if it is medium and 1 if it is fertile
Vist_Agt	Number of visits by the extension agents
pl_dis	the average distance of the plots from the house of household
Slope	Slope of the plot
Tlu	The total livestock unit owned by the household
Fer_Exp	Fertilizer used by the household in Birr
Illness	Illness of the household , As a dummy variable having a value of 1if yes, 0 otherwise
Mkt_dis	minimum market distance access agricultural inputs
Y	Total output value in birr

*Birr is Ethiopian currency 1USD=8.61Birr and 1USD=7.00 Birr during the period when the data was collected in 2004 and 2009 respectively.

** Subscripts for household number (*i*) and year (*t*) are omitted to improve readability.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Descriptive statistics of the variable

As mentioned in the previous chapter this thesis uses two years panel data set from 2004 and 2009 from four different rural regions. It compiles 16 woreda [1] and 20 peasant associations. Only about 23.04% of the sample households are female headed households, while the remaining 76.96% are male headed households. The average age of the household head is 48. The average family size of the sample is about 5.65 and 5.68 in 2004 and 2009 respectively. The labour contribution to the production process is 3.05 which is obtained by multiplying the age and the sex with conversion number that considered from the age of 10 to 65 years, which is assumed as the labour force that participates in the production process (Annex 2).

Education has an important role to impact on the livelihood of the households. However, the level of education in the study area is very low with an average of 1.7 school years. About 53% of the heads of households have no schooling, 17.4% have some religious and technical training, 20.7% have elementary school, 4.9% have secondary school, 3.5% have high school, and only 0.5% has higher education.

The farmers produce more than 60 items of different agricultural outputs over the different regions considered. Some of the major crops are teff, sorghum, wheat, maize, barley, vegetables, enset and coffee. Output is the sum of farm income from crops and livestock. In order to make the output proper for the estimation of the model, I aggregate to one output by changing outputs into similar unit and weighting by the respective prices of the outputs considered.

[1] **Woreda**: equivalent unit of district according to Ethiopian administrative unit

The farm size is calculated by converting the local measure of the land unit changes to one standard unit, hectare. Land is very scarce in Ethiopia in which we find the average land holding to be 1.6 hectare per household. Soil fertility on average is about 2, considering three range of choices of one as fertile, two as medium and three as bad. The average plot slope is 2.5 per household, again among the range of three possible choices of one steepest, two medium and three flat. The average distance of the household farm from the house is 13.6 minutes. The average distance to the local market is 29.9 minutes. Mixed farming is common in Ethiopia. On average the households own 3.5 total livestock units (Obtain by multiplying the animal with the conversion factor placed in the annex 1).

The average fertilizer expense of the households is 398 in Ethiopian *birr*. 48.6% of the households that use fertilizer, and application rates are generally very low as compared to the recommended amount of fertilizer usage (150 kg per hectares) (UNDP, 1993).

Table 4.1 Descriptive some statistics

Variable	Mean	Std. Dev.	Min	Max
Y	**3786.4**	**138.2**	**1.1**	**57472.5**
Age	**48.1**	**14.9**	**18.0**	**95.0**
Labour	**3.1**	**1.5**	**0 .2**	**9.7**
Land	**1.6**	**1.4**	**0.0**	**10.9**
Fer_exp	**398.1**	**605.9**	**0.0**	**7000.0**
Tlu	**3.4**	**3.5**	**0.0**	**23.5**
Mkt_dis	**30.0**	**42.4**	**0.0**	**240.0**
Educ	**1.8**	**2.9**	**0.1**	**15.0**
Vist_Agt	**1.1**	**2.8**	**0.0**	**60.0**
slope	**2.5**	**0.5**	**1.0**	**3.0**
soil_fer	**2.0**	**0.8**	**1.0**	**3.0**
plot_dis	**13.5**	**12.5**	**0.0**	**120.0**

The Ethiopian currency is birr, the exchange rate during 2004 and 2009 1 USD=8.8 Birr and 1USD=12.00 respectively.

4.2 The Cobb-Douglas production function

Random effect regression analysis on the Cobb-Douglas production function is applied to see the correlation between the dependent variable (the value of production) and explanatory variables that are assumed to be the most important inputs for production in the study area. In log form this yields expression (11) which is repeated for the readers' convenience:

$$\ln Y_{it} = \beta_0 + \beta_1 \, Area_{it} + \beta_2 \, \text{LabourEq}_{it} + \beta_3 \, \text{Age}_{it} + \beta_4 \, FertUse_{it} + \beta_5 \, TLU_{it} + \beta_6 \, Av\ land\ quality_{it} + \ldots + \beta_{ij} 2009 dummy_i + V_{it} - U_{it} \quad (11)$$

Table 4.2 Cobb-Douglas production estimation

Independent variables	Dependent variable: Agricultural production (Value in Ethiopian *Birr*)	
	Coefficient	**Standard error**
Age	0.003	(0.005)
Sex	-0.211	(0.191)
Labour	0.312***	(0.098)
Land	0.344***	(0.056)
Ferti	0.052*	(0.026)
Vist_Agt	-0.306**	(0.110)
Tlu	0.055	(0.054)
Pl_dist	0.269***	(0.069)
Mkt_dist	0.059**	(0.030)
Educ	0.073***	(0.028)
Illness	-0.624***	(0.122)
Slope	0.345***	(0.119)
soil_fer	-0.268***	(0.075)
Constant	4.807***	(0.456)

Significant level***=1%, ** =5%, *=10%. The values in the parentheses are the standard errors.

The regression results indicate that the factor inputs labour, land, education are significantly and positively affect production at 1% significant level. Similarly, fertiliser expense is positively correlated with production at the 5% significant level. Soil fertility affects the production negatively, which implies that the improvement in the quality of the land fertility increases the output production level. The estimation of illness variables affects the production negatively and significantly at 1% level of significance. It has the highest elasticity of 0.62. The estimation of gender variable turns out to be negative and insignificant. The linear specification of variable age has no significant impact on production. Similarly total livestock units are insignificant on the production. Plot distance and market distance have unexpectedly influence the production positively and significantly which is against the expectation.

4.3 Stochastic frontier analysis and technical efficiency

Table 4.3 presents the maximum likelihood estimate results of the stochastic production frontier. The estimation results in Table 4.3 are not very different from Cobb-Douglas estimation result in Table 4.2 It shows that the parametric estimation of all inputs including land, labour, soil fertility and fertilizer influence agriculture production significantly and positively. The output elasticity of land (0.34) is the highest compared to the other variables labour (0.19), soil fertility (0.33) and fertilizer (0.08). Illness is hypothesized to have negative correlation with production. As expected, it has the high negative elasticity of 0.53 implying that the illness is an important factor that affects level of production negatively. Other explanatory variables, such as the parameter estimate of distance to the market and the plot affect production level positively and significantly, which is contrary to what expected. The total livestock unit and plot slope are insignificant to affect production.

Table 4.3 Stochastic frontier analysis

Dependent variable(Y):	**Agricultural production value (Birr)**	
Independent variable	Coefficient	Standard errors
Labour	0.193***	0.081
Land	0.342***	0.055
Slope	0.083	0.101
Soil_fer	-0.337***	0.064
Fer_exp	0.089***	0.021
Visit_Agt	-0.258***	0.091
Tlu	0.033	0.046
Pl_dist	0.235***	0.052
Mkt_dist	0.090**	0.024
Illness	-0.532***	0.102
Constant	8.023***	0.294
σ_s^2	6.835***	0.785
γ	6.835**	0.785
μ	-353.500	272.000

Significant level***=1%, ** =5%, *=10%. The value in the parentheses is the standard errors

The technical efficiency for the i^{th} firm is defined in terms of the ratio of its mean production to the corresponding mean production if the firm effect was zero. A predictor for this measure of technical efficiency is presented. The technical efficiency score is predicted from the stochastic frontier estimation.

The table present the levels of efficiency score of those exposed to illness and not exposed to illness.

Table 4.4 the technical efficiency scores

Efficiency Level	Exposed to Illness (n=1119)	Not Exposed to illness (n=1278)	Total (n=2397)
Greater than 0.85	0	0	0
0.75-0.85	0	0	0
0.65- 0.75	1	1	2
0.55-0.65	119	622	741
0.45- 0.55	327	482	809
Less than 0.45	672	173	845
Mean %	0.335	0.489	0.417
Maxima%	0.680	0.680	0.680
Minima %	0.001	0.025	0.001

Production efficiency scores lie within the range of 0 and 1. Efficiency scores illustrated in Table 4.4 indicates that for the households not exposed to illness exhibit relatively higher technical efficiency score than those exposed to illness. The average score of efficiency for those exposed to illness is 0.33, whilst for those not exposed to illness is 0.48 And the overall efficiency score is very low being only 0.42. In order to check the significance of the differences t-test are used. It checked the hypotheses set in the objective that the health's of the household significantly affect the production efficiency. The t-test efficiency score reject the hypothesis that has no differences between the two groups of efficiency score (illness and not exposed to illness).

4.4 Factors influencing production efficiency

Before analyzing factors influencing production efficiency, it is necessary to see the distribution of U_{it} against theoretical assumptions. Based on the theoretical assumption mentioned above the V_{it}-random variables are assumed to be independent and identically distributed i.e. N $(0,\sigma^2)$. Whereas, U_{it} random variables, which are assumed to be independent and identically distributed. U_{it} are truncated at zero and takes non-negative value i.e. N (μ, σ^2). The kernel density estimates in figure 2 bellow illustrated the estimation prediction obtained in the regression analysis satisfied with assumption in the theory.

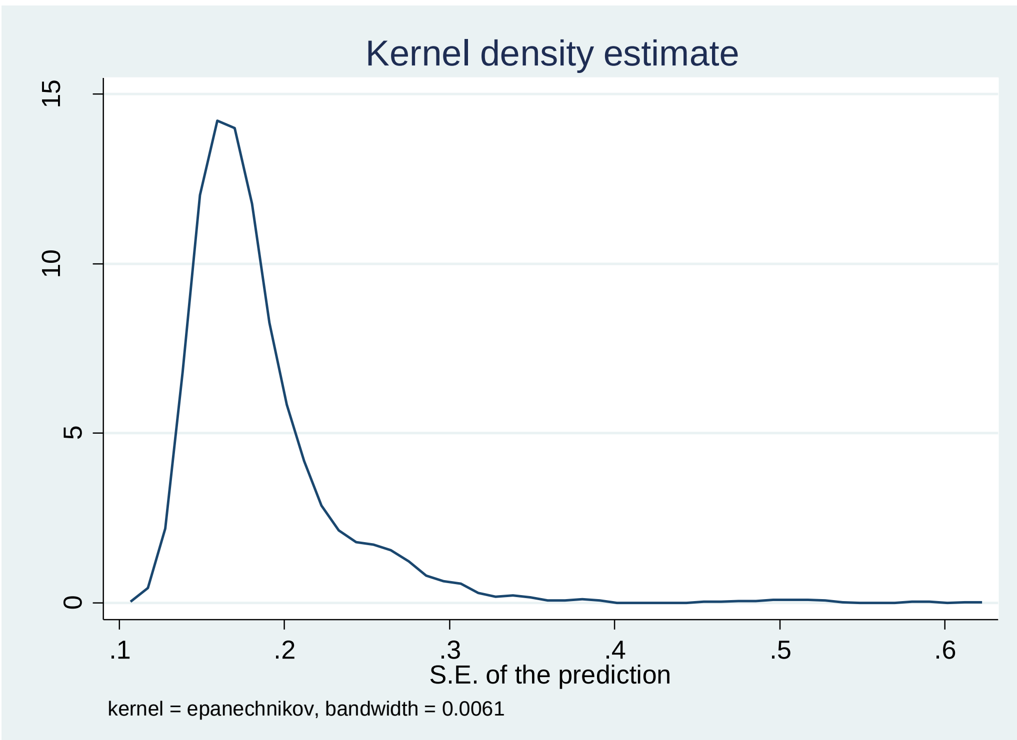

Figure 2. Kernel density estimate

The next stage is to analyze factors influencing production efficiency. The estimation obtained from the regression result is given in Table 4.5

Table 4.5 Factors influencing production efficiency

VARIABLES Names	Coefficient	Standard error predication
Age	0.000**	5.03e-05
Sex	0.005***	0.001
soil_fer	-0.001	0.001
Slope	0.005***	0,002
educ	0.005***	0.001
Labour	-0.014***	0.001
Land	-0.022***	0.001
Fer_exp	0.001***	0.000
Visit_Agt	0.026***	0.001
Tlu	-0.007***	0.001
Pl_dit	0.001***	0.001
mkt_dist	0.002***	0.000
Illness	0.003***	0.001
Year	0.001	0.000
Constant	-0.157	0.727
σ_s^2	-6.213	0.000
γ	0.547***	0.091
µ	-0.026*	0.014
Observation	1183	

Table 4.5 shows the maximum likelihood parameter estimates of the stochastic production frontier of productivity U_{it} predicted from the SFA estimated results of Table 4.3. The likelihood

estimation parameters show that the variables sex, age, education, slope, visited by extension agent fertilizer expenditure, plot distance and market distance parameters, are significant and positive, while land and labour are negative and significant. The later could be due to the excess surplus labour leading to diminishing return to scale. The parameter estimate for illness is positively significant with productivity estimation; it is contrary to the expectation. Moreover, technological change is also unexpectedly statistically insignificant.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

This thesis studies the effect of health on agricultural production and comparers the effect of health on production efficiency of the smallholder farmers in Ethiopia. It tried to answer two operational research questions: i) Does health affect agricultural production? and ii) Is agricultural production efficiency affected by farmer's health?

To answer these research questions I used Ethiopian longitudinal household survey data from the year 2004 and 2009, covering 1183 households. I applied Cobb Douglas stochastic frontier analysis. The Cobb-Douglas frontier estimation explains the relationship between farm output and inputs. Input variables such as land, labour, soil fertility and fertilizer influence agriculture production significantly and positively. The output elasticity of land (0.34) is the highest compared to the other variables labour (0.19), soil fertility (0.33) and fertilizer (0.08). The estimated coefficient for illness is negative and significant as expected with high elasticity (0.53), whilst the parameter estimation of distance to the market and the plot unexpectedly has positive correlation. The total livestock unit becomes insignificant to the production.

Technical efficiency scores were derived from the CD stochastic frontier estimation model. The analysis result indicated that the households exposed to illness have on average 33.5% technical efficiency score, while the households not exposed to illness score 48.9% and the overall technical efficiency score exhibit very low average technical efficiency of 41.7%. These results suggested that health affects agricultural production as indicated by my first research question.

Moreover, my likelihood estimates showed that the variables sex, age, plot, slope, fertilizer expenditure and market distance parameters, are significant and positive in influencing production efficiency.

In general, the health impact has statistically significantly influenced the production of the households in the study area. Thus, it implies that it is very important to give emphasis on the quality of the health system as it has significant impacts on the productivity of farm households. Since the majority of the Ethiopian economy relies on the agricultural sector, it is essential to take into consideration possible factors that lead to gains in agricultural production efficiency. On this issue, my findings in this paper can be seen as a start to researches on these issues.

At the same time, my results are sufficiently strong to suggest that it is important to design projects that improve the health status of the farm households along with the agricultural extension packages.

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Annexes

Appendix 1: Conversion factors used to compute tropical livestock unit (Tlu)

Animal category	Tlu
Calf	0.25
Heifer	0.75
Cow/Ox	1.00
Horse	1.10
Donkey	0.70
Sheep/Goat	0.13
Chicken	0.013
Bull	1.00
Camel	1.00
Mule	0.70

Source: Storck, et al, 1991

Appendix 2: Conversion factors to drive adult equivalent

Age group(yrs)	Male	Female
<10	0.0	0.0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1.0	0.8
>50	0.7	0.5

Source: Storck, et al, 1991

Appendix 3: Conversion factors to change land unit to hectare

Unit	Conversion factor
1 Gasha	40
2 Hectare	1
3 Gemed	0.25
4 Timad	0.25
5 Kert	0.25
6 Massa	0.67
7 Kufaro	0.025
8 Zhir	0.0003
9 Others	0.000025
10 TINTO	0.06
11 ERMIJA	0.0001
12 DERO	0.045
13 GEZEM	0.1666
14 KEND	0.000025
15 SQUARE METER	0.0001
16 BOY	0.1