Ethiopian Economics Association (EEA)

PROCEEDINGS OF THE FOURTH REGIONAL CONFERENCE OF THE SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGIONAL STATE ECONOMIC DEVELOPMENT

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FOREWORD

The Ethiopian Economic Association (EEA) and its Hawassa Chapter are happy to issue the proceeding of the Fourth Annual Conference on the Southern Nations and Nationalities People Regional State Economic Development which was organized on March 28, 2014 at the BoFED Conference Hall. EEA organized this important regional conference as one of its objectives of broadening its activities and coverage at regional level so as to contribute to the economic advancement of regional state through enhancing economic policy formulation capability; the dissemination of economic research findings; promotion of dialogue on critical socio-economic issues; promotion of education in economics in higher learning institutions; enhancing national, continental and global networks of professionals and institutions; and advancement of the professional interests of its members.

The Annual Regional Conferences that the Association has organized in collaboration with its Hawassa Chapter has created important forums for presenting and discussing development issues that are highly relevant to the Regional Socio-economy. These forums have also provided incentives for researchers to conduct research and present their findings on regular basis. Indeed, the Annual Regional conferences were organized in an interdisciplinary fashion, thereby widening the interactive coverage involving both economists living here in the region and those living outside the region and non- economists who are working and experiences on the region. The Fourth Annual Regional Conference on Southern Nation and Nationalities People Regional State Economic Development has contributed towards a deeper understanding of the regional economy and the complex challenges it faces. It attracted about 130 participants including the higher officials and expertise from Regional Bureaus, Universities, NGOs, private sector representative and EEA members in the region. The participants of the conference expressed their satisfaction on the organization of the conference and the content of the papers presented. They reflected that the papers largely focused on local issue that can contribute to the development of the region. They also recommended that the issues raised in the discussion are critical that need due attention by policy makers and implementing organs of the region.

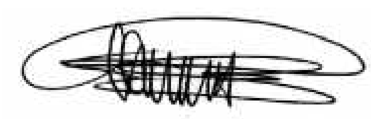
In this publication, all papers which were presented at the Fourth Annual Conference, and reviewed by external reviewers and comments and suggestions including editorial comments were communicated to authors for improvement. Finally, the papers which passed all the review and editorial process published in the Proceeding of the Fourth Annual Conference on the Southern Nation and Nationalities People Regional State Economic Development.

I would like to take this opportunity to express my heartfelt gratitude, on my own behalf and on behalf of the Ethiopian Economic Association, to the many people and organizations that made the conference resounding success. First and foremost, I thank the authors of the papers and the audience whose active participations made the Conference meaningful. The staffs of the Economics Department of the Hawassa University which runs the EEA Hawassa Chapter, organizers from Wolaita Sodo, Arba Minch and Dilla Universities and the staff of EEA Secretariat deserve a special recognition for their passion and perseverance in managing the conference from inception to completion. Hawassa University also deserves appreciation for hosting EEA Chapter by providing office.

Our special thanks go to our partners who have shared our vision and provided us with generous financial support to materialize the activities of EEA. These include; The Friedrich Ebert Stiftung of Germany, The African

Capacity Building Foundation (ACBF), The Think Tank Initiative of International Development Research Center (IDRC) of Canada; Civil Society Support Program (CSSP), The Norwegian Church Aid, The Royal Netherlands Embassy, The Swedish Embassy through SIDA, The Development Cooperation of Ireland (DCI) the Ireland Embassy, and the British Embassy through DFID.

Finally, I would like to thank the Bureau of Finance and Economic Development of the Southern Nation and Nationalities People Regional State for allowing us to use its conference hall and its facility free of charge since the start of this important regional conference and sponsoring the conference partially.



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FACTORS AFFECTING ECONOMIC EFFICIENCY IN MAIZE PRODUCTION: THE CASE OF BORICHA *WOREDA* IN SIDAMA ZONE, SOUTHERN ETHIOPIA

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Abstract

Maize is an important crop for food security in Ethiopia as a source of both food and income. Hence , due emphasis should be given required to enhance productivity through improvement of efficiency of resource usage in maize production, The objective of this paper was to determine the levels of economic efficiency of smallholder maize producers and to link the observed efficiency levels to farmers' socioeconomic and institutional characteristics in Boricha Woreda, Southern Ethiopia. A multi-stage sampling technique was used to select 204 sample farmers who were interviewed using a structured questionnaire to obtain data pertaining to maize production during 2013. In the analysis, frontier 4.1c software was used to determine the levels of technical and economic efficiencies. Thus, the mean technical and allocative efficiencies were 72 and 70 percent, respectively while the mean economic efficiency was 53 percent. Furthermore, descriptive statistics, stochastic frontier and a two-limit Tobit regression models were employed. It was established from a stochastic frontier model that maize yield estimated using Cobb-Douglas production function was positively influenced by seed, labor, oxen, farm size, DAP and Urea fertilizers. Similarly,

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a Tobit model revealed that economic efficiency was positively and significantly affected by education, trainings, membership to cooperatives, utilization of credit, and family size whereas variables such as age, distance to extension center and market, livestock and off-farm income affected it negatively. Thus, the study recommended policies targeting training, membership to cooperatives development of markets, roads and education of smallholder maize producers that would promote economic efficiency of maize producers.

Keywords: *efficiency, smallholder maize producers, SFA, two-limit Tobit regression*

1. Introduction

Africa produces 6% of the total world maize production, most of which is used for human consumption (Reynolds, 1999). Governments in East and Southern Africa have given top priority to maize production, because maize in this sub region is as important as rice and wheat in Asia (Byerlee and Eicher, 1997). Maize is an important crop for food security of Ethiopian households and is a source of calorie available at the lowest cost compared to all other major cereals. On average Ethiopia consumes a total of 1,858 kilocalories daily of which four major cereals (maize, *teff*, wheat, and sorghum) account for more than 60 percent, with maize and wheat representing 20 percent each (Shahidur *et al*., 2010). It has also continued to be an important cereal crop in the SNNPRS as a source of both food and cash income (Million and Getahun, 2001).

Maize is the single most important crop in terms of both number of farmers engaged in cultivation and crop yield (Shahidur *et al*., 2010). The smallholder farmers that comprise about 80 percent of Ethiopia's population are both the primary producers and consumers of maize (Dawit *et al*., 2008). Eight million smallholders were involved in maize production during 2008/09 production season, compared to 5.8 million for *teff* and 4.5 million for sorghum, the second and third most cultivated crops in Ethiopia, respectively. In 2007/08, maize production was 4.2 million tons, 40 percent higher than *teff*, 56 percent higher than sorghum, and 75 percent higher than wheat production (Shahidur *et al.*, 2010).

The Ethiopian government has put a lot of much effort in promoting agricultural productivity and efficiency of smallholder farmers (Jema, 2008) since agriculture continues to be the dominant sector in Ethiopia's economy. Shahidur *et al*. (2010) showed that cereals account for 65 percent of the agricultural value added, equivalent to about 30 percent of the national GDP. The role of maize is central to agricultural policy decisions as a prime staple food for food security and overall development of the agricultural sector. The increase in crop production in the past decade has been due to increases in area crops cultivated areas. But to what extent the area cultivated can continue to expand remains an important question. Even expansion of cultivated area will have to come almost exclusively from reduction in pasture land. Given also high population growth and the limits of area expansion, increasing productivity by enhancing efficiency and intensive usage of resources will lead to achieve more yield and food supply to overcome malnutrition and poverty. Hence improvements in resource usage efficiency and increasing productivity will reduce encroachment of population to marginal agricultural lands.

The agricultural sector productivity is one of the lowest which is even showing a decreasing trend with causing a decline in per capita cereal consumption (Jema, 2008). Why has productivity in maize production remained low in the study area? Previous studies have not addressed such question of the low efficiency of maize production in the area. In addition to this, no studies have tried to differentiate socioeconomic factors that affect economic efficiency of smallholder maize producers. However, existing studies were related to maize varieties and technological adoption areas. Thus, there is considerable scope to expand output and also productivity by increasing efficiency and sustaining the efficiency of those operating at or closer to the frontier. Improvements in efficiency and productivity lead to achieve more maize output and food supply which reduce malnutrition and poverty. Therefore, the general objective of this study was to measure the levels of economic efficiency and examine factors that affect economic efficiency in maize production among smallholders in Boricha *Woreda* of Sidama Zone in SNNPR. The specific objectives of the study were to measure levels of technical, allocative and economic efficiencies in maize production among smallholder maize producers, to identify the demographic, socio-economic and institutional factors that affect economic efficiency in maize production and to estimate the level of responsiveness of maize yield to the main inputs of production, namely seed, labor, oxen and fertilizers.

2. Literature Review

Important factors affecting the efficiency of smallholder maize producers were found to be oxen holding, farm size, use of maize seed, education level, use of fertilizer, herbicides, farmers' age and experience, distance of the plot to the main access road, household size/labor, gender, usage of hand hoe, off farm income, farmers' membership to associations, access to development agents, and access to credit (Boris, 1997; Ephraim, 2003; Elibariki, 2008; Zalkuwi, 2010). This section reviews the effects of some of important demographic, socio economic and institutional factors on efficiency of smallholder maize producers in detail.

2.1 Age of household head and efficiency

Older farmers are more experienced in farming activities and are better to assess the risks involved in farming than younger farmers (Rebecca, 2011). As a result, age of household head contributes positively to technical efficiency. This implies that as age of the decision maker increases, technical efficiency will increase. This may be perhaps due to the fact that farmers learn from their experience about the allocation of inputs (Essa *et al*., 2011).

In addition to this, Zalkuwi (2010) identified that older farmers in maize production are more cost efficient than younger ones. However, this is in disagreement with the analyses of Boris (1997) and Khan and Saeed (2011) which showed that age contributes negatively to efficiencies, meaning that younger farmers were relatively more efficient than older farmers. This is an important finding which notes that younger farmers are comparatively more educated than older farmers. Thus, they inferred from their finding that the younger and educated the farmer, the more technically and economically efficient he is. Similarly, findings of Simonyan *et al*. (2011) explained that younger farmers were technically efficient than their aged counterparts.

2.2 Sex of the household head and efficiency

Reducing inequalities in human and physical capital between male and female farmers will potentially increase output and technical efficiency (Rebecca, 2011). However, according to Mignouna *et al*. (2012) who assessed the technical efficiency of maize producers in Western Kenya, no significant difference was observable in the sex of the household head although the groups vary significantly in terms of their educational level.

Ephraim (2003) described the insignificance of the sex of the farmer, although suggesting that female controlled maize plots are more efficient, which shows that gender is not an important factor in explaining efficiency. However, according to Chiona (2011), male households are likely to be wealthier and capable of adopting new and expensive agricultural technologies. On the other hand, female farmers are more likely to attend meetings and adopt the best production practices.

2.3 Household size and efficiency

Rebecca (2011) explained that even though smallholder farmers mainly depend on family labor; they still hire labor to argument to the family efforts. Farmers with smaller family size are the ones who usually hire labor. Hired labor helps in accelerating production at the various stages of farming. Therefore, it eases the labor constraint faced by most smallholder farms.

Household size plays an important role in maize production and most farmers depend mainly on family labor. However, study results imply that there is a negative relationship between household size and technical efficiency. Boris (1997) showed that the number of people in a household has a negative association with allocative efficiency. The reason according to Essa *et al*. (2011) is that a household with a large family size needs more resource to satisfy its energy and food requirements. Therefore, to meet these needs, resources will be exploited more extensively that leads to expansion to marginal lands leading to environmental degradation, implying a decline in productivity. However, Mignouna (2012) states that the household size has an ambiguous effect. It is associated with the availability of timely labor and in this case, larger families are likely to be more efficient. On the other hand, a larger family with more dependents decreases efficiency in farming due to low supply of farming labor.

2.4 Education level of the household head and efficiency

Education potentially enhances farm efficiency and knowledge with regard to agricultural production. Educated farmers apply better farming methods. They are also better placed to try newer forms of farming (Rebecca, 2011). Boris (1997) showed that younger and more educated farmers exhibited higher levels of technical efficiency. In addition, Chiona (2011) used education as a proxy for human capital to show that a higher level of education may lead to better management of farming activities.

Khan and Saeed (2011) agree that the higher the level of formal schooling by farmers, the higher the technical, allocative and economic efficiencies. This is because educated farmers are likely to access information easily, and use it to make well informed decisions. However, these findings contradict with some studies by Zalkuwi (2010) which showed that farmers' level of cost efficiency tend to decline with education.

2.5 Farm size and efficiency

Rebecca (2011) states that land plays an important role in farming as one of the most available resources one can use efficiently. According to Endrias *et al*. (2013) and Rebecca (2011) farm size is highly significant for positively affecting the technical efficiency of smallholder maize producers. However, this finding does not agree with that of Ephraim (2003), which shows that land and the interacting variables with land are negatively related to maize output. Essa *et al*. (2011) described that total area cultivated during the long rainy season has a positive and significant effect on technical inefficiency. The results imply that farm size increases technical inefficiency. Perhaps, timely and appropriate agricultural operation on larger land size with traditional technology may not be effective which leads to a higher level of inefficiency. Moreover, larger plot size in the study areas implies larger fragmentation of plots which are widely scattered, making it difficult for farmers to work on all their fields at the same time. Larger plot size may also mean expansion of agricultural lands to marginal areas which makes efficient crop production difficult. As a result, efficiency and productivity can be negatively affected when plot size is large given the current level of technology.

2.6 Seeds used and efficiency

There is a positive impact and significant relationship between seed and output (Oyewo, 2011).Seeds were divided into three categories: certified hybrid seed, Open Pollinated varieties and recycled hybrid and local varieties. Farmers who use certified hybrid seed are expected to have higher efficiency levels (Chiona, 2011). According to Rebecca (2011) most small-scale farmers who practice subsistence farming do not buy certified seeds, but they use recycled seeds that are stored after every harvest, while others buy recycled seeds from their fellow farmers. This practice affects the crop output every year in terms of quantity as well as quality. Hybrid maize seeds play an important role in maize production. Most smallholder maize producers use the same seed they used previously. After harvesting they store some of the maize in order to use it in the next planting season, a practice which hampers the effort of trying to increase productivity. According to Endrias *et al*. (2013) and Ephraim (2003) the use of hybrid maize variety positively affected the technical efficiency of smallholder maize producers. Farmers who were users of hybrid maize variety were technically more efficient than non-users.

2.7 Fertilizer application and efficiency

Fertilizer plays a vital role in maize production since no matter how large and small the farm size is, if it is applied properly, yields will increase.

Smallholder farmers tend to have difficulties in obtaining fertilizer as they lack financial means. There is a positive relationship between fertilizer and technical efficiency of smallholder maize producers at Ga-Mothiba in South Africa. The use of chemical fertilizer is known to be the commonly used method in improving productivity and in the intensification of agricultural production as a whole; it also plays a big role in regions where the scarcity of farm land is a big problem (Rebecca, 2011).

2.8 Oxen usage and efficiency

According to Endrias *et al*. (2013) the relationship between oxen holding and technical efficiency in maize production was positive. Thus, oxen availability is crucial to increase technical efficiency in maize production. However, according to Elibariki (2008) smallholder farmers using hand hoe are found to be more efficient compared to those using tractor and/or ox-plough. The government's agricultural policy encourages farmers to use tractors and ox-plough. But this policy is a mismatch holding a mismatch with realities at the farm level. Small and fragmented land holdings make it difficult to attain economies of scale for smallholders using tractors. This implies, given the current landholdings and smallholder's resource base, investment in highly mechanized agriculture might not necessarily translate to high productivity.

2.9 Membership to farmers' cooperatives and efficiency

Farmers` associations play an important role in organizing members into input cooperatives and in creating access to financial services from state and NGO sectors and seeking access to other financial development agencies. The Rebecca (2011) study shows that farmers who are members of farming organizations are rather small as compared to those who are non-members. For small-scale farmers it is important to be organized in order to get access to credit which they can use to buy new improved inputs, especially seed to increase technical efficiency. Farmers` organizations play an integral role in maize production and efficiency through dissemination of latest agricultural information to other farmers, and buying seeds in bulk for sharing. Therefore, this may have an impact on smallholder as many become efficient. This means that farmers' organizations influence technical efficiency, and there is a positive relationship between the organization and the technical efficiency of smallholder maize producers.

The role of social capital in providing incentives for efficient maize production in the study of Ephraim (2003) is revealed by the negative and statistically significant relationship between club membership of a household and technical inefficiency. The sharing of information on crop husbandry at club or association level tend to filter to other members of households that are not members or through demonstration effects of farming practices on club or association members' plots. Thus club membership has some external effects on family members that are not members of the farming clubs (Ephraim, 2003). However, this is in disagreement with Essa *et al*. (2011) who showed membership of households to a farmers' association contributes negatively to economic efficiency. This suggests that farmers who belong to associations are found to be economically inefficient. This situation can happen if membership in the associations and participation, if any, are nominal and the decision making process does not take in-to account the needs of the members. Particularly, if agricultural information and technology transfer through associations do not address the needs of the poor farmer and the marginal including women, efficiency and productivity will not improve.

2.10 Credit utilization and efficiency

Access to credit contributes positively to technical inefficiency. This implies that farmers who utilize credit are less technically efficient than those who do not. This might happen due to various possible reasons. Firstly, if the credit system is not responding to the needs of farmers in terms of amount, time and repayment procedure, the service might rather increase rather than reduce inefficiency. Secondly, the level of loan diversion problems and inappropriate use of funds by farmers may also cause the service to be ineffective in reducing inefficiency. Finally, absence of competitive credit systems can tighten the alternatives regarding collateral requirements, time of repayment and interest rate determination and conditions regarding failure to repay loans (Essa *et al.*, 2011). This is in disagreement with the findings of Khan and Saeed (2011), which showed that receiving credit contributed positively to the farmers' efficiency; access to credit may enable farmers to purchase productive inputs on time. It may lead to higher productive efficiencies. This shows that the higher the access to credit, the more efficient the farmer becomes. If production credit is invested on the farm, it is expected that this will lead to higher levels of output. Thus, access to credit is more likely to lead to an improvement in the level of technical and allocative efficiency (Simonyan *et al*., 2011).

2.11 Methodological Review

Efficiency is generally measured using either DEA or stochastic frontier methods. Some of the advantages of stochastic frontiers over DEA are it accounts for measurement of errors and other sources of statistical noise, can be used to conduct conventional tests of hypotheses. The disadvantages include the need to specify a distributional form for the inefficiency term and the need to specify a functional form for the production function or cost function, *etc*. (Coelli *et al.*, 2005). The stochastic parametric method decomposes random errors into error of farmer's uncontrollable factors, as well as farm specific inefficiencies. While deterministic and non-parametric method has drawbacks since it forces all outputs to a frontier yet sensitive to outliers if large, it distorts efficiency measurements (Ogundele and Victor, 2006; Douglas, 2008). Khan and Saeed (2011) specified the stochastic frontier production functions model as follows:

$$Y_i = f(X_i ; \alpha_i) + \varepsilon_i$$

Whereby Y_i is the output of farmer i, X_i are the input variables, α_i are production function coefficients and ε_i is the error term.

The farm specific technical efficiency in terms of observed output (Yi) to the corresponding frontier or potential output (Yi*) is:

$$TE_i = \frac{Y_i}{Y_i *} = \frac{E(Y_i|u_i , X_i)}{E(Y_i|u_i = \sigma , X_i)} = e^{-\left[E\left(\frac{u_i}{\varepsilon_i}\right)\right]}$$

In order to estimate farm level overall economic efficiency, the stochastic frontier cost functions model is specified as follows:

$$C_i = h(Y_i, P_i; \alpha_i) + \varepsilon_i$$

Here C_i is the total production cost, Y_i stands for output produced, P_i is price of input, αi represents the parameters of the cost function to be estimated and ε_i is the error term. Since, inefficiencies are assumed to add to costs, error components, therefore, have positive signs.

The farm specific economic efficiency is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C) (Khan and Saeed, 2011):

$$EE_i = \frac{C_i^*}{C_i} = \frac{P_i^{'} X_i^*}{P_i^{'} X_i} = \frac{E(C_i | u_i, = o, Y_i, P_i)}{E(C_i | u_i, Y_i, P_i)} = e^{\left[E\left(\frac{u_i}{\varepsilon_i}\right)\right]}$$

The model was run by frontier 4.1 program and it should be noted that the frontier 4.1 program estimates the cost efficiency (CE), economic efficiency (EE) is then obtained from the inverse of cost efficiency as follows (Ali *et al.*, 2012).

$$EE = {}^{1}/_{CE}$$

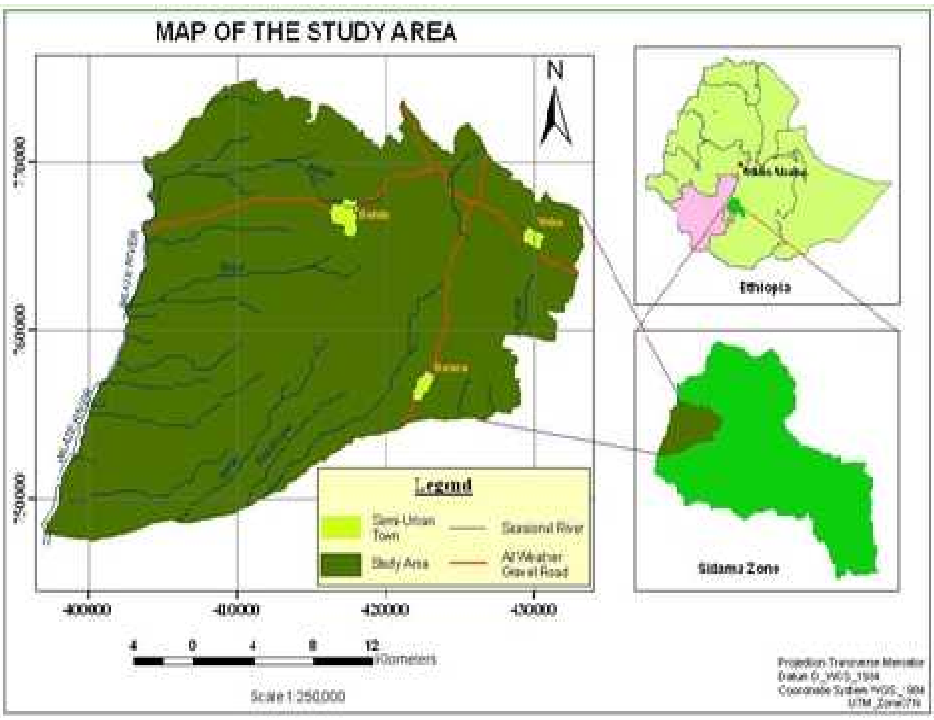
3. Research Methodology

3.1 Description of the Study Area

This study was carried out in Boricha *Woreda* which is found in Sidama Zone in southern Ethiopia (Figure 3.1). Boricha *Woreda* is bordered on the south, by Lake Abaya *Woreda*, on the west by the Wolayita Zone, on the northwest by the Oromiya region, on the northeast by Hawassa Zuria *Woreda*, on the east by Shebedino *Woreda*, and on the southeast by Dale *Woreda*. It has an estimated area of 588.05sq km that comprises of 39 *Kebeles* of which 3 are urban and the remaining rural. It extends from the lowest point at south west of the mouth of the tributary of Bilate River at 1320m.a.s.l to north east at 2080m.a.s.l (Bechaye, 2011). Boricha *Woreda* has a total population of 250,260, of whom 125,524 are men and 124,736 women. Only 4.16% of its population is urban. The major crops by coverage are maize, haricot bean, coffee, horticultural crops and *teff* (CSA, 2007). The study area uses a large amount of land for maize production. However, since use of agro-chemicals irrigation and manure are not practiced maize production is very low. In this area, cultivation of maize takes more share of the land allotted for crop production.

There are two cropping seasons in the study area, i.e., *Belg* (short rainy season) which runs from March to May and *Meher* (main rainy season) which occurs in the months of June to September. *Belg* rains are mainly used for land preparation and planting long cycle crops such as maize. The *Meher* rains are used for planting potato, green paper, haricot bean, sweet potato and to some extent *teff* (Bechaye, 2011). The area generally depends on rain fed agriculture and uses mixed farming. Both crop production and animal husbandry are commonly practiced. The main crops grown during the two cropping seasons are maize, haricot bean, potato, green pepper, sweet potato, and in some parts sugar cane and *enset*. The main livestock species are cattle, goats, sheep and poultry. Major cash crops are maize, haricot bean, potato, green paper.

Figure 3.1: Administrative **map of the Boricha Woreda**



Source: Bechaye (2011)

3.2 Data Type and Source

The study used both secondary and primary data to attain the stated objectives. The secondary data was collected from different sources including research papers, booklets, internet, BoFED, EEA, CSA, Zone and *Woreda* sector offices, and unpublished materials. The primary data was collected through household survey and key informant interviews from sample households using a structured questionnaire. Moreover, focus group discussions were held with 10-15 farmers, local administrators and development agents. During the survey, information was gathered on issues related to the socioeconomic factors that affect economic efficiencies in maize production in the study area, farmers' knowledge about the production of maize,inputs used and output produced.

3.3 Sample Size Determination and Sampling Technique

3.3.1 Sample size determination

The following formula was used in the determination of sample size (Israel, 1992), because the proportion of efficient and non efficient is unknown the number of total population is known; hence the following formula is appropriate formula for this study

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size needed, N is the population size of the study area (= 280576), and e is the desired level of precision (in this case, e= 7%) with the same unit of measure as the variance and e^2 is the variance of an attribute in the population.

Then, the sample size (n) was calculated as follows,

$$n = \frac{280576}{1 + 280576(0.07)^2} = 204$$

Therefore, a total of 204 households were selected for the study from four *Kebeles* by using random sampling method. The population size of the *Woreda* was obtained from the Agriculture and Rural Office of the *Woreda*.

3.3.2. Sampling techniques

A multi-stage stratified sampling technique was used to select sample farmers in Boricha *Woreda*. In the first stage, the study *Woreda* was purposively selected based on the extent of maize production. In the second stage, Boricha *Woreda* was grouped into three livelihood zones based on the way of living. These livelihood zones are Agro-Pastoralist Livelihood Zone (APLZ), Coffee Livelihood Zone (CLZ) and Maize Livelihood Zone (MLZ). Each livelihood zone has 5, 10, and 24 *Kebeles,* respectively (Bechaye, 2011). In the third stage, two *Kebeles* from maize Livelihood Zone, one *Kebele* from Agro-Pastoralist Livelihood Zone and also one *Kebele* from Coffee Livelihood Zone were selected based on the extent of maize production, number of *Kebeles* in each zone and discussion with extension officers. Consequently, Koran Gogi and Konsore Arki *Kebeles* from maize Livelihood Zone, Shelo Elancho *Kebele* from Agro Pastoralist Livelihood Zone and Alabo Arke *Kebele* from Coffee Livelihood Zone were randomly selected from the respective livelihood zones. Finally, 64, 46, 36 and 58 households from a total of 1614, 1430, 1123 and 1587 households were randomly selected from Koran Gogi, Konsore Arke, Shelo Elancho and Alawo Arke *Kebeles,* respectively, resulting in a total sample size of 204 households. The sample size was distributed in each sample *Kebele* based on the population size.

3.4 Methods of Data Analysis

The data collected from different sources were analyzed by using both descriptive statistics and econometric methods. The descriptive method includes simple ratios, percentages, tables, frequencies, standard deviations, *etc*. The quantitative and qualitative data were tabulated in a way that can enable understanding factors that affect economic efficiency in maize production. Frontier computer programming (version 4.1) software was used for estimating the farm-specific economic efficiency scores of maize producers in the study area. Following that the efficiency score was taken as a dependent variable and was then regressed against farmer specific, demographic, socioeconomic and institutional factors.

The purpose of using econometric method was to estimate effects of inputs on maize output by using stochastic frontier production model with maximum likelihood estimation, and factors that affect economic efficiency of smallholder maize producers by using two-limit Tobit model in Boricha *Woreda*. The qualitative data was also summarized and presented to supplement the result of the quantitative analysis.

3.5 Analytical Framework and Model Specification

3.5.1 Cobb-Douglas stochastic frontier production function Model

According to Kopp and Smith (1980), empirical studies relating to developing countries have used Cobb-Douglas functional forms. The Cobb-Douglas functional form also meets the requirement of methodology employed that needs cost and production functions should be self-dual. However, Rebecca (2011) showed that the Cobb-Douglas production function model has a number of limitations. The major criticism is firstly that it cannot represent all the three stages of neoclassical production function, representing only one stage at a time. Secondly, the elasticities of this type of function are constant irrespective of the amount of input used.

However, regardless of these limitations the Cobb-Douglas production function is used as the functional form of the production function for its mathematical simplicity and linearity in its logarithmic form. In addition to this, Boris *et al*. (1997) described that Cobb-Douglas functional form is used to specify the stochastic production frontier, which is the basis for deriving the cost frontier and the related efficiency measures. The specific Cobb-Douglas production model estimated is given by:

$$Y_i = \beta_0 * \prod_{i=1}^{n} X_i^{\beta_i} * e^{(V_i - U_i)} \quad (1)$$

By transforming it into double log-linear form:

$$\ln Y_i = \ln\beta_0 + \beta_i \sum_{i=1}^{6} \ln X_i + (V_i - U_i) \quad (2)$$

Where Y_i represents maize yield harvested and X_i represents maize production inputs by i^th^ farmer. Whereas $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 are the regression parameters to be estimated and ln= *natural logarithm*. From the error term component $(V_i - U_i)$, V_i is a two sided $(-\infty < V < \infty)$ normally distributed random error ($v \sim N[0, \sigma^2_v]$) that represents the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise while U_i is a one-sided ($u_i \geq 0$) efficiency component which is independent of v_i and is normally distributed with zero mean and a constant variance (σ^2_u) allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

3.5.2 Two-limit Tobit model with maximum likelihood estimation

Following Amemiya (1981), Waluse (2011), Essa *et al*. (2011) and Endrias *et al*. (2013) the two-limit tobit model was defined as:

$$Y_i^*{}_{EE,\ TE,\ AE} = \delta_0 + \sum_{j=1}^{12} \delta_j Z_{ij} + \mu_i \qquad (3)$$

Where Y_i^* is the latent variable representing the efficiency scores, $\delta_0, \delta_1, \ldots, \delta_{12}$ are parameters to be estimated, and EE, TE and AE are economic, technical and allocative efficiency of the i^{th} farmer, respectively. Z_i is demographic, socio economic and institutional factors that affect efficiency level. And μ_i= an error term that is independently and normally distributed with mean zero and variance δ^2 ($\mu_i \sim IN\left(0, \delta^2\right)$). And, farm-specific efficiency scores for the smallholder maize *producers* range between zero and one. Therefore, two-limit Tobit model can be presented as follow

$$Y_i = \begin{cases} 1, & \text{if } Y_i^* \geq 1 \\ Y_i^*, & \text{if } 0 < Y_i^* < 1 \\ 0, & \text{if } Y_i^* \leq 0 \end{cases} \qquad (4)$$

Two-limit Tobit model allows for censoring in both tails of the distribution (Greene, 2003). The log likelihood that is based on the doubly censored data and built up from sets of the two-limit Tobit model is giver by

$$\ln L = \sum_{y_i = l_{0i}} \ln \Phi \left[\frac{l_{0i} - X'_i\beta}{\sigma}\right] + \sum_{y_i = y_i^*} \ln \frac{1}{\sigma} \emptyset \left[\frac{y_i - X'_i\beta}{\sigma}\right] + \sum_{y_i = l_{1i}} \ln \left[1 - \Phi\left(\frac{l_{1i} - X'_i\beta}{\sigma}\right)\right] \qquad (5)$$

Where L_{0i} = 0 (lower limit) and L_{1i} = 1 (upper limit) where Φ and $\emptyset$ are normal and standard density functions.

The coefficients of variables represented by the above equations were estimated by the STATA command using specific options. In efficiency analysis, it is not only the level of inefficiency that is important, but the identification of the socioeconomic and institutional factors that cause it. Eventhough the approaches for the identification of these factors may vary to some extent with the methodology employed, the most commonly followed procedure in both approaches is what is usually referred to as the two-step procedure (Jema, 2008). First, the efficiency or an inefficiency index is estimated. Second, the inefficiency or efficiency index is taken as a dependent variable and is then regressed against a number of other explanatory variables that are hypothesized to affect efficiency levels.

In a Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. By following McDonald and Moffitt (1980), Greene (2003)and Gould *et al.* (1989) cited in Endrias *et al*. (2013), from the likelihood function decomposition of marginal effects was proposed as follows two-limit Tobit model:

The unconditional expected value of the dependent variable

$$\frac{\partial E(y)}{\partial x_j} = [\phi(Z_u) - \phi(Z_L)].\frac{\partial E(y*)}{\partial x_j} + \frac{\partial[\phi(Z_u) - \phi(Z_L)]}{\partial x_j} + \frac{\partial[1 - \phi(Z_u)]}{\partial x_j} \tag{6}$$

The expected value of the dependent variable conditional upon being between the limits

$$\frac{\partial E(y*)}{\partial x_j} = \beta_m.\left[1 + \frac{\{Z_L \varphi(Z_L) - Z_u \varphi(Z_u)\}}{\{\phi(Z_u) - \phi(Z_L)\}}\right] - \left[\frac{\{\varnothing(Z_L) - \varphi(Z_u)\}^2}{\{\phi(Z_u) - \phi(Z_L)\}^2}\right] \tag{7}$$

The probability of being between the limits

$$\frac{\partial[\Phi(Z_u) - \Phi(Z_L)]}{\partial x_j} = \frac{\beta_m}{\sigma}[\phi(Z_L) - \phi(Z_u)] \quad (8)$$

Where, $\Phi(.)$ = the cumulative normal distribution,
$\phi(.)$ = the normal density function
$Z_L = -\frac{X'_i\beta}{\sigma}$ and $Z_u = \frac{(1-Xi\beta)}{1}$ are standardized variables that came from the likelihood function given the limits of y* and σ = standard deviation of the model.

3.6 Descriptions of Variables

3.6.1 Variables in stochastic frontier Cobb-Douglas production model

Table 3.1 presents the hypothesized effects of different inputs on total maize output. In the model the dependent variable was harvested maize output of one season in a year. Explanatory variables that were expected to affect this dependent variable were presented as follows. All dependent and independent variables are in the form of natural logarithm.

Table 3.1: Variables in stochastic frontier Cobb-Douglas production function model

Variables	Description of variables	Unit of measurement	Hypothesized sign
Seed	Quantity of weighted maize seed	Kg	+
Labor	Number of weighted labor	Person equivalent-days	+
Oxen	Number of weighted oxen	Oxen-days	+
Dap	Quantity of DAP fertilizer	Kg	+
Urea	Quantity of Urea fertilizer	Kg	+
Farm size	Maize cultivated farm size	*Timad*	+

Note: 1 *timad*=1/4 of a hectare
Source: Own construction, 2013

3.6.2 Variables in two-limit Tobit regression model

Table 3.2 presents the hypothesized effects of different farmers and farms, and socio-economic and institutional variables on efficiency. In the model the dependent variables were economic, technical and allocative efficiency scores which were regressed against the following common independent variables. A number of explanatory variables were expected to influence the economic, technical and allocative efficiencies directly or indirectly. Explanatory variables that were expected to affect these dependent variables were presented as follows.

Table 3.2: Description of variables in two-limit Tobit regression model

Variable	Description of variable	Measurement	Hypothesized sign
Sex	Sex of household head	Male=1, Female=0	+
Age	Age of the household head	Person-equivalent	+
Yearedu	Formal education level of household head	Number of grade	+
Training	Received training on maize production	Yes =1, No =0	+
Membcoop	A membership of farmers to cooperatives	Yes =1, No =0	+
Credit	Utilization of credit for maize farming	Yes =1, No =0	+
Disexten	Distance to the extension service (s) office	Km	-
Dismkt	Distance to the main market	Km	-
Famlsize	Household family size	Number	+
Farmsize	Total maize cultivated farm size	Timad	-
Livestock	Livestock size of household	TLU	+
Offfarm	Off-farm activities of household	Birr	+

Source: Own construction, 2013

4. Results and Discussion

Econometric results of the stochastic frontier and Tobit models were presented and discussed specifically, elasticities and return to scale which were measured from stochastic production function. In addition, the estimated efficiency scores and factors influencing efficiency in maize production were also discussed based on the results from two-limit Tobit model.

4.1 Stochastic frontier production function

Determination of elasticities is necessary for the estimation of responsiveness of output to inputs. Most of the inputs on the stochastic frontier were statistically significant and had the expected signs. Lambda (λ) was also statistically significant (Table 4.1). This is evidence of the fact that there were measurable inefficiencies in maize production probably caused by differences in socio-economic characteristics of households and their farm management practices.

Farm size was the important factor of production, having an elasticity of 0.2582. This implies that a one percent increases in farm size used in *timad* increase the total output by about 0.3 percent. This result agrees with the findings of (Edet *et al*., 2006). Urea fertilizer also appeared to be an important factor, with an elasticity of 0.2085. This implies that a one percent increase in a urea fertilizer increases the total output by about 0.2 percent. In addition, DAP fertilizer had a significant effect on maize production with an elasticity of 0.1088, meaning a one percent increase in its use would increase output by 0.1 percent. Again, labor had an elasticity of about 0.1717. This is consistent with the observation that maize production in the study area is labor intensive. Therefore an increase in labor, measured in man days, by one percent increases total maize farm output by about 0.2 percent while all other factors are held constant.

The elasticity of production with regard to seed use was 0.1464 and significant at 1 percent level. It further means that a one percent increase in the quantity of seed used for maize production, holding all other inputs constant, results in 0.15 percent increase in maize output. Similarly, the effect of oxen holding on maize production was positive. The use of oxen power in farm operations such as land preparation, planting and weeding was significant in influencing maize output. Table 4.1 shows that the sum of the elasticities for all variables was 0.9588 which is less than one which means that the farm households were operating at a point of decreasing returns to scale. This is the rational return to scale in the production function at which production should normally take place because output is increasing positively at a diminishing rate with an increase in inputs utilization. This is consistent with findings of Baloyi (2012) on technical efficiency in maize production in South Africa and Hasan (2008) on economic efficiency in Northern Region of Bangladesh

Table 4.1: Regression results of stochastic frontier production function

Variable	Coefficient	Standard error	z-value
Constant	5.9906	0.00017	3.4e+04
Seed	0. 1464***	0.00004	3226.75
Labor	0. 1717***	0.00039	440.27
Oxen	0. 0652***	0.00059	110.27
Dap	0. 1088***	0.00010	1028.77
Urea	0. 2085***	0.00007	2934.93
Farmsize	0. 2582***	0.00038	670.58
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.3775	0.03738	
$\gamma = \sigma_u^2/\sigma^2$	0.9999		
$\lambda = \frac{\sigma_u}{\sigma_v}$	3463481	0.03041	
Returns to Scale (RTS)	0.9588		

Number of obs = 204 Wald chi2(6) = 1.80e+09

Log likelihood = -48.705838 Prob > chi2 = 0.0000

Log likelihood-ratio test of sigma_u=0: chibar2(01) = 7.84 Prob>=chibar2 = 0.003

*** Estimates are significant at 1% level

Source: Model output (2013).

4.2 Efficiency scores levels and distribution

The result showed that technical efficiency indices of sample farmers ranged from 0.15 to 0.94 (Table 4.2). The higher distributions of the technical efficiency level classes were 0.71 to 0.80 and 0.81to 0.90 with each category representing 28.43 percent of the total sample. And the average technical efficiency was found to be 0.72. This indicates that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 23 percent reduction of wastage in inputs use to produce his most efficient counterpart output. Similarly, manner, the most technically inefficient farmer in the sample was to achieve the technical efficiency level of his most efficient counterpart; then the least efficient farmer could realize 84 percent reduction of the wastage in inputs use to produce the output of the most efficient counterpart. This indicates that there was a substantial amount of technical inefficiency in maize production.

The mean allocative efficiency of the sample was 0.70, with a minimum of 0.17 and a maximum of 0.98. The higher distributions of economic efficiency level classes were 0.71 to 0.80 and 0.81to 0.90 with each category representing 19.61 and 28.92 percent of the total sample, respectively. The average economic efficiency level for the sample farmers was 0.53, with a minimum of 0.10 and a maximum of 0.91. These figures indicate that if the average farmer in the sample was to reach the economic efficiency level of his most efficient counterpart, then the average farmer could realize 41 percent of total production cost savings. Similarly the most economically inefficient farmer could realize 89 percent total production cost savings. In sum, it is evident from these results that technical efficiency could be improved substantially, and that economic efficiency constitutes a more serious problem than allocative efficiency.

Table 4.2: Frequency distribution of TE, EE, and AE of maize producers

Efficiency	TE		EE		AE	
Range	Frequency	%	Frequency	%	Frequency	%
0.00-0.10	0	0.00	0	0.00	0	0.00
0.11-0.20	1	0.49	20	9.80	1	0.49
0.21-0.30	1	0.49	24	11.76	11	5.39
0.31-0.40	7	3.43	15	7.35	10	4.90
0.41-0.50	11	5.39	29	14.22	19	9.31
0.51-0.60	23	11.27	24	11.76	19	9.31
0.61-0.70	28	13.73	30	14.71	21	10.29
0.71-0.80	58	28.43	46	22.55	40	19.61
0.81-0.90	58	28.43	12	5.88	59	28.92
0.91-1.00	17	8.33	4	1.96	24	11.76
Total	204	100.00	204	100.00	204	100.00
Mean	0.7285		0.5354		0.705	
Minimum	0.1586		0.1023		0.179	
Maximum	0.9480		0.9159		0.987	

Source: Model output (2013).

4.3 Factors influencing economic efficiency of smallholder maize producers

Table 4.3 shows the two-limit Tobit regression results of EE scores against socioeconomic and institutional variables. The economic efficiency model showed that ten out of twelve variables were statistically significant at influencing economic efficiency of sample farmers. These include age, education, membership to cooperatives, training, distance to development agents and main market, off-farm income, credit, livestock, and family size.

Economic efficiency was significantly influenced by age of household head at 1 percent level. Age contributed negatively to the economic efficiency in this study; in other words, younger farmers were relatively more efficient than older farmers. The reason could be younger farmers had more contacts with extension agent cervices, plot demonstration and agricultural meetings.

Since, education is used as a proxy for human capital, it potentially enhances farm efficiency and knowledge with regard to agricultural production. According to this study the education level of a household head was highly significant affecting positively economic efficiency of smallholder maize producers. The reason is that educated farmers were able to apply better and newer forms of farming methods. Similarly Chiona (2011), Dolisca and Curtis (2008), Rebecca (2011), and Khan and Saeed (2011) found that the higher the level of formal schooling, the higher economic efficiency becomes. Younger farmers were comparatively more educated than the older farmers. Therefore, by increasing the education status of older farmers through Adult Based Education and Training, the government can increase the efficiency level of farmers. This is because educated farmers are likely to access information easily, and make well informed decisions with better management of farming activities. This result is consistent with the result of Boris (1997) and Khan and Saeed (2011) which explains that the more educated the farmer, the more technically and economically efficient he becomes.

Training farmers about farm management is important for farmers to improve their skills and practices. It was positively related with economic efficiency of farmers at 1 percent level. It was established that participating in farmers' training program increased the possibility of efficiently using farm inputs. Training helped farmers to obtain information and to correct misconceptions concerning input usage. Organizations that provide inputs to farmers usually verify that whether farmers received some training or not before they provide inputs. Therefore, building the capacity of the existing farmers' training centers and expanding their coverage as well as strengthening the field level training programs are highly demanded to improve maize production system.

Membership to cooperatives was found to be positively related and significantly affecting economic efficiency of smallholder maize producers in the study area at 1 percent level. Farmers` organizations played an important role in organizing members into input cooperatives and in creating access to inputs and extension officers. Economic efficiency was also influenced by credit. The results showed that credit had a positive influence on economic efficiency and it was significant at 10 percent level. Specifically, it was observed that utilization of credit was important in production in the sense that it improved farmers' ability to purchase the otherwise unaffordable farm inputs. Therefore credit has a great potential for improving farm economic efficiency in the study area. This finding is similar to that of Waluse (2012) and Dolisca and Curtis (2008) who found that farmers who used credit were more efficient.

Farmers who were closer to the office of extension centers had more contacts with extension agents. They were able to participate in agricultural meetings, field days, demonstration plots and best available practices. As result, farmers closer to the extension services were more efficient than their counterparts. Thus, distance to the extension center was found to be negatively related and significantly affecting economic efficiency of smallholder maize producers in the study area at 1 percent level of significance.

Distance to the main market was also found to be negatively related and significantly affecting economic efficiency of smallholder maize producers at 1 percent level. This result showed that there were areas that transport vehicles could not reach. Farmers under these conditions face difficulties to reach improved technology, transport inputs and farm produce easily.

Family size was found to positively and significantly affect economic efficiency of maize farmers at 1 percent level. This means that, as number of household members increases, there might be a more equitable labor distribution among farming activities. Results of this study match with findings of Douglas (2008) that found family size had a positive and significant effect on production efficiency.

Raising livestock affected maize production economic efficiency significantly and negatively at 5 percent level of significance. This is consistent with that increased TLU takes away farmers' efforts that could otherwise be used for maize production and hence reduces efficiency of smallholder maize producers. Additionally, the findings indicated that off-farm income had a negative and significant effect on economic efficiency. This might be the case if the type of off-farm activity prevents the farmer from attending to his/her farm.

The results showed that, other variables keep constant, a unit increase in age of the farmer decreases the expected value of economic efficiency by about 0.3 percent. Similarly, a unit increase in TLU owned by a household decreases economic efficiency by about 0.3 percent. However, a unit increases in family size of a household increases expected value of economic efficiency by about 3.4 percent. A unit increase in distance to the market decreases economic efficiency of small holder maize producers by about 1.8 percent. The result is attributed to the fact that a farmer located far from the market incurs more costs to transport farm inputs from the market, compared to the one closer to the market. The findings are consistent with results found by Waluse (2012). In a similar manner, a unit increase in distance to extension centers decreases economic efficiency of small holder maize producers by about 1.2 percent with other variables kept constant.

A one year increase in education of a household head increases expected value of economic efficiency of a farmer by about 0.5 percent. Additionally, an increase in the dummy variable representing training increases an expected value of economic efficiency of farmers by about 2.9 percent. Again, an increase in the dummy variable representing membership to farmers' input cooperatives increases an expected value of economic efficiency of farmers by about 5.6 percent keeping other variables constant. Specifically, it was found that an increase in utilization of credit increases farmers' expected value of economic efficiency by about 1.3 percent.

Table 4.3: Tobit regression estimates of factors influencing economic efficiency

Variable	Coefficient	Robust standard error	t-value
Constant	0.614***	0.051	12.10
Sex	-0.011	0.009	-1.28
Age	-0.003***	0.000	-3.33
Yearedu	0.005***	0.001	3.50
Training	0.029***	0.008	3.56
Membcoop	0.056***	0.007	7.85
Credit	0.013*	0.007	1.89
Disexten	-0.012***	0.004	-3.21
Dismkt	-0.018***	0.005	-3.66
Famlsize	0.034***	0.004	8.57
Farmsize	0.004	0.002	1.56
Livestock	-0.003**	0.001	-2.08
Offfarm	-0.000***	0.000	-2.72
Log pseudolikelihood = 443.035		F(12, 192) = 1312.12	Prob > F = 0.0000

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Model output (2013).

4.4 Factors influencing technical efficiency of smallholder maize producers

According to the results of Tobit regression model, important variables affecting the technical efficiency were found to be sex, age, membership to cooperatives, training, distance to extension agents and main market, credit, family size, livestock and off-farm income (Table 4.4). In this study, women farmers were found to be more efficient than their men counterparts. According to focus group discussion, the reason was that female farmers were more likely to attend meetings, frequent follow-ups and supervisions of their farms than males. This result is consistent with findings of Chiona (2011) and Dolisca and Curtis (2008) that found the negative relationship between sex and technical efficiency. Under this study, age was significant at negatively affecting the technical efficiency of smallholder maize producers. This result is in line with findings of Simonyan *et al*. (2011) that younger farmers were more technically efficient than their aged counterparts. Boris (1997) showed also that younger and more educated farmers exhibited higher levels of technical efficiency.

Family size was also found to affect technical efficiency level negatively and significantly at 1 percent level. This was due to poor managerial ability to effectively utilize the available labor force in the family. However, there was a positive relationship between technical efficiency and training. Farmers attending field days and agricultural meetings organized by extension centers had easier access to extension center services than those who do not participate in any group training. This implied that the contribution of training on maize farmers' production efficiency was very high. Farmer's cooperatives influenced technical efficiency significantly at 5 percent level of significance and there was a positive relationship between membership to farmers' cooperatives and the technical efficiency of smallholder maize producers. Farmers' cooperatives played a significant role by disseminating agriculture information to the farmers and helped them access extension center services easily. This result is similar to the findings of Dolisca and Curtis (2008) who found that membership to cooperatives contributed positively to technical efficiency.

The relationship between livestock and technical efficiency was positive and statistically significant at 10 percent level. Farmers were able to raise funds for the purchase of inputs especially fertilizer which was more costly. According to focus group discussion, some of livestock especially oxen were used for ploughing and weeding fields; others like donkeys, horses and mules were used for transporting goods and people. Female animals provided the households with milk while animals' dung was a source of fertilizer and fire wood.

Table 4.4 showed that credit had a negative influence on technical efficiency and it was significant at 10 percent level. This result is similar to that of Essa *et al*. (2011) who found that credit contributed negatively to technical efficiency. The reason of this finding was that most of farmers did not get credit on time to purchase required inputs for production and some farmers used credit purposes other than agricultural activities, like food purchase, children's education. Additionally, farmers that were closer to the extension officers and main markets had more access to attend agricultural meetings, field days, demonstration plots, road and input access. The negative sign of parameter for this variable is similar to the priori expectations of the study. Thus, distance to the extension centers and markets were found to be negatively related and significantly affecting technical efficiency of small scale maize producers in the study area. The result suggests that technical efficiency of sample farms would significantly increase with the development of road and market infrastructure that reduce home to market distance.

A change in the dummy variable sex (from 0 to 1) decreases expected value of technical efficiency of farmers by about 1.6 percent. Other variables being constant, a unit increase of age of household head decreases expected value of technical efficiency of a farmer by about 0.7 percent. Additionally, an increase in access to credit would decrease expected value of technical efficiency of farmers by about 0.8 percent.

Table 4.4: Tobit regression estimates of factors influencing technical efficiency

Variable	Coefficient	Robust Standard error	t-value
Constant	1.350***	0.045	30.02
Sex	-0.016***	0.004	-3.39
Age	-0.007***	0.001	-10.54
Yearedu	0.000	0.001	0.80
Training	0.045***	0.008	5.82
Membcoop	0.017**	0.007	2.33
Credit	-0.008*	0.005	-1.73
Disexten	-0.014***	0.003	-4.95
Dismkt	-0.020***	0.004	-4.77
Famlsize	-0.021***	0.003	-6.27
Farmsize	0.000	0.002	0.13
Livestock	0.002*	0.001	1.66
Offfarm	0.000**	0.000	2.08
Log pseudolikelihood = 478.64	F(12, 192) = 593.81	Prob > F = 0.0000	

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively
Source: Model output (2013).

A TLU increase in livestock increases the mean level of technical efficiency by 0.2 percent keeping other variables constant. However, a unit increase of family size of a household decreases expected value of technical efficiency of farmers by about 2.2 percent. Additionally, it was also found that an increase in the distance to the market by one km, leads to a decrease in the farmers technical efficiency by about 2 percent, other variables being constant. An increase in the dummy variable representing training increases expected value of technical efficiency of farmers by about 4.5 percent. And increase in membership to farmers' cooperatives also increases expected value of technical efficiency. Farmers who were members to farmers' cooperatives improved their technical efficiency levels by 1.7 percent compared to those who failed to join farmer groups assuming that other variables are kept constant.

4.5 Factors influencing allocative efficiency of smallholder maize producers

The results in Table 4.5 show the estimates from the two-limit Tobit regression model regarding the relationship between efficiency scores and, socioeconomic and institutional factors.

Age of a household head was significant and had a positive effect on allocative efficiency of smallholder maize producers. Training was positively related with allocative efficiency of smallholder maize producers at 1 percent level. Participating in farmers' training program increased the possibility of efficiently using farming inputs. Similarly, membership to cooperatives was found to be positively related and significantly affecting allocative efficiency of smallholder maize producers in the study area at 1 percent level (Table 4.5). The reason was that membership to cooperatives created access to inputs and extension service in the study area. Family size was also found to be positively and significantly affecting allocative efficiency of maize farmers at 1 percent level.

The negative and significant effect of off-farm income on allocative efficiency indicated that farmers engaged in off-farm income earning activities tend to exhibit lower level of allocative efficiency. According to this study, involvement in non-farm activities were accompanied by reallocation of time away from farm related activities, such as adoption of new technologies and gathering information that is essential for enhancing allocative efficiency. Additionally, distance to the extension service centers was found to be negatively related and significantly affecting allocative efficiency of smallholder maize producers in the study area at 1 percent level.

Table 4.5: Tobit regression estimates of factors influencing allocative efficiency

Variable	Coefficient	Robust Standard error	t-value
Constant	0.303	0.068	4.42
Sex	-0.007	0.009	-0.78
Age	0.002**	0.001	2.45
Yearedu	0.000	0.001	0.49
Training	0.047***	0.010	4.40
Membcoop	0.056***	0.010	5.53
Credit	0.008	0.008	1.06
Disexten	-0.014***	0.003	-3.99
Dismkt	-0.004	0.007	-0.64
Famlsize	0.058***	0.006	9.68
Farmsize	0.000	0.003	0.20
Livestock	-0.001	0.001	-0.83
Offfarm	-0.000***	0.000	-3.32
Log pseudo likelihood = 397.42073		F(12, 192) = 527.54 Prob > F = 0.0000	

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively
Source: Model output (2013).

A unit increases in age of a farmer increases allocative efficiency by about 0.3 percent. A unit increase in family size also increases expected value of allocative efficiency by about 5.8 percent with other variables kept constant. However, a unit increase in distance to extension centers decreases expected mean level of allocative efficiency by about 1.4 percent. An increase in the dummy variable representing training increases expected value of allocative efficiency of farmers by about 4.8 percent. An increase in membership to farmers' cooperatives increases expected value of allocative efficiency. Farmers who were members to farmers' cooperatives improved their allocative efficiency levels by 5.6 percent compared to those who failed to join farmer groups assuming that other variables are kept constant.

4. Summary

With highly increasing population growth and the limited expansion of cultivable area of land, due emphasis should be given to productivity and efficiency of resource usage to prevent malnutrition and poverty. More importantly, efficient resource use is the basis for achieving food security and poverty reduction strategies, and the objective of this study was to evaluate farm level economic efficiency for maize crop production and the factors influencing economic efficiency level of smallholder maize producers in Boricha *Woreda*, southern Ethiopia. Thus a multi-stage sampling technique was used to select 204 sampled farmers which were interviewed using structured questionnaire to obtain data pertaining to farm production, input usage, and other variables including socioeconomic and institutional factors. A Cobb-Douglas production function was employed to assess maize output elasticity. Various tests were also conducted to prove the working hypotheses. Additionally, frontier 4.1c software was used to determine the levels of technical and economic efficiencies. Furthermore, descriptive statistics, a stochastic frontier and a two-limit Tobit regression models were employed.

It was also established from a stochastic frontier model that maize yield was positively influenced by seed, labor, oxen, Dap and Urea fertilizers and farm size. The mean technical and allocative efficiencies were 72 and 70 percent, respectively, while the mean economic efficiency among smallholder maize producers was 53 percent. Based on parameters tests, σ^2 (0.376) and γ (0.999), the study established that smallholder maize producers used resources inefficiently.

Tobit regression model estimation also revealed that economic efficiency was positively and significantly affected by education, training, membership to cooperatives, access to credit, and family size whereas variables such as age, distance to extension officers, distance to market, livestock and off farm income affected it negatively. Generally, development of market and road infrastructure could promote resource use efficiency and increase productivity. Hence policy makers should focus on development of market and road infrastructure so as to facilitate market participation and integration of far away resident smallholder maize producers. Consequently, policies targeting and encouraging training, membership to cooperatives and access to education of smallholder maize producers promote economic efficiency of maize production in the study area.

6. Conclusion and Recommendations

According to the findings, maize output was positively influenced by labor and oxen usage. A contribution of labor and oxen was positive indicating policies that motivate and mobilize the farm labor and oxen power in agricultural activities would be likely to lead to higher maize output. Urea and DAP fertilizers also appeared to be the major underlying determinants of maize output. Similarly the use of improved maize seeds was found to be vital for increasing farmers' maize output. However, farmers' use of these inputs has been challenged by shortage of supply and high prices. Therefore, the government should provide improved seeds and fertilizers at subsidized prices. In addition, to encourage the use of improved maize seeds and fertilizers, distribution of these inputs should be on credit basis. Farm size also was an important input of maize production. Younger farmers were comparatively more educated than the older farmers. Therefore, by increasing the education status of older farmers through Adult Based Education and Training, the government can increase the efficiency level of farmers.

In this study training was a major underlying determinant of economic, technical and allocative efficiencies. It was found to have a positive and significant effect on technical, allocative and economic efficiencies. Providing continuous training to smallholders and follow-up smallholders' farming activities about input usage during maize production is therefore important. As a result, extension service centers should give trainings to the farmers so as to increase their efficiencies in maize production. This will substantially help smallholder maize producers to survive and achieve food security. This requires more efforts of government and NGOs to increase farmers' training and education on better using inputs. If such knowledge is disseminated, farmers will improve their technical, allocative and economic efficiencies which will result in increased maize output and higher food security.

Membership to farmers' cooperatives was found to affect technical, allocative and economic efficiencies positively and significantly. Therefore, it should be encouraged and strengthened to improve access to market information and other extension services. When farmers are better organized it becomes easier even for extension staff to offer extension services to the farmers. Therefore, it implies that cooperatives should have clear and agriculture oriented missions. Moreover, there must be active participation of farmers through giving leadership especially to those marginalized people including women that help member farmers to increase their resource use efficiency. However, distance to extension service centers and market were found to have a negative influence on technical, allocative and economic efficiencies of smallholder maize producers. Thus, development of market and road infrastructure could promote resource use efficiency and increase productivity. Therefore policy makers should focus on development of market and road infrastructure so as to facilitate market participation and integration of far away distant resident smallholder maize producers.

Raising livestock affected maize economic efficiency significantly and negatively. This might be due to the fact that increased TLU of livestock diverts farmers' efforts away from maize production and hence reduces efficiency of smallholder maize producers. Additionally, the findings indicated that off-farm income had a negative and significant effect on economic efficiency. This might be the case if the type of off-farm activity deprives the farmer from running his/her farm.

The study has shown that farmers having access to credit were more technically efficient than those with no access to credit services. This means that there should be access to credit services for smallholder farmers at reasonable market interest rates, on time and in the needed amount to help farmers acquire inputs. Furthermore, utilization of credit should be provided with continued complementary agricultural support services, including training. Additionally, improvements in farm efficiency rely on institutional capacity building for farmers. As a result, policy makers should focus on providing institutional support to farmers rather than focusing on introducing new technologies in which if the necessary technical and managerial skills are not in place, it may result in continued inefficiencies in maize production.

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DETERMINANTS OF FOOD INSECURITY STATUS OF RURAL HOUSEHOLDS: A CASE STUDY OF HAWASSA ZURIA WOREDA IN SIDAMA ZONE, SOUTHERN ETHIOPIA

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Abstract

A better understanding of factors affecting the status of food insecurity at micro level is required for the organizing technical research, the development of policies and for shaping the direction of future actions for food self-sufficiency. This study was conducted to measure household food insecurity and its determinants in Hawassa Zuria Woreda of Sidama zone 192 randomly selected households were used for study. In addition focus group discussions were conducted in the selected Kebeles with a participation of 8-10 people on average. Descriptive statistics such as mean, standard deviation, percentage and frequency distribution as well as logistic regression model and household hangar scale were employed to analyze data. Chi-square (X^2) and t-tests were also used to describe characteristics of food secure and food insecure groups. According to the results 38 percent of sample respondents were food insecure, and 62 percent were food secure. The result of the household hunger scale analysis indicated that 69; 25 and 6 percent of respondents were found in categories of little to no hunger, moderate hunger, and sever hunger, respectively. The result of the binary logistic regression model revealed that seven out of thirteen variables namely, household size, cultivated land size in hectare, animal resources holdings measured in TLU, participation in extension packages, access to credit services farm income and literacy status of household heads were found to be statistically significant determinants of household food insecurity in the study

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area. During food insecurity households used different strategies including intercropping, engaging in daily labor, selling livestock, seasonal migration and reducing frequency and amount of meals served for members, the. To decrease food insecurity, the findings suggest the following set of policy recommendations: awareness creation and provision of family planning at family, community and national level, resettlement programs, and soil and water conservation activities on degraded farm, increase farm income, timely provision of credit and delivery of inputs, increasing production and productivity of livestock and provision of formal and non- formal education.

Key words: Household hunger scale, logistic regression, copying strategies

1. Introduction

Food insecurity is a situation when people, groups or individuals within groups lack physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Lomborg, 2004). According to Bouis and Hunt (1999), it occurs when people do not have enough food to eat according to accepted cultural norms due to various reasons affecting availability, access, and utilization. Similarly, the International Federation of Red cross Societies and Crescent (IFRCSC, 2005) as indicated that malnutrition, hunger, under weight, wasting, stunting, low birth weights, high child mortality, lower cognitive development and low productivity are some of the consequences of food insecurity.

In the World Food Summit held in 1996, world leaders met in Rome and made a commitment to decrease the number of food insecure people by half not later than the year 2015. After some years, the world food summit tried to evaluate its activities in food security programs but the trend showed that it is unlikely to meet its target even by 2015 (FAO, 2003;

Madley, 2000). This means that the problem of food insecurity may occupy the attention of policy makers for long thus urging them to make sustainable interventions.

Food insecurity is a universal problem. According to the Food and Agriculture Organization, (FAO) 925 million people are undernourished and the problem largely affects developing countries (FAO, 2010).For instance, out of 925 million people, about 97 percent live in developing countries. The majority of these food insecure people live in rural areas of Africa, Asia, and Latin America where infrastructure is less developed. FAO (2010) indicated that Africa has the largest proportion of its people rated as food insecure (26 percent). Sub-Saharan Africa is the only region where the number of food insecure population increased between 1992 and 2010 (FAO, 2010). Ethiopia is at the bottom of the least developed countries where millions of households, particularly in the rural areas, suffer from chronic and temporary food insecurity (DFID, 2006).

Since Ethiopia is one of the poor countries in Sub-Saharan Africa, about 39 percent of the rural households fall below the nationally defined food security line i.e. 2200 kilo calories plus essentials food items, and the average proportion of undernourishment increased to 41 percent between year 2006 and 2008 (FAO, 2011). Similarly, the United Nations Development Program's (UNDP) human development report for the year 2011 ranked Ethiopia 174th out of 187 in its human development index Bichaye (2011) reported that the number of food insecure households in the country has been increasing while per capita food availability has been decreasing. In this regard, Woldeamlack (2009) indicated that the average per capita food availability was 128.908 kg for the period 1960 to1974, and the food availability declined to 119.99 kg for the period 1975 to 1991. The impacts

went to the extent that importing and providing food aid was taken as a possible solution to fill the gaps between food demand and supply.
The International Food Policy Research Institute pointed out it is indexing (IFPRI, 2009) that Southern Nations, Nationalities and Peoples Regional State (SNNPS) is the fourth food insecure region in Ethiopia. Out of the total 134 *Woredas*, more than half were deemed to be chronically food insecure, prone to drought and suffering from food shortage. According to SNNPR bureau of agriculture and rural development, on average about 1,360,568 beneficiaries have been food insecure. Hence, these beneficiaries have been targeted for productive safety net program (PSNP) since 2005 (BoARD, 2012). In particular, the Sidama Zone Agriculture and Rural Development Department (SZARD, 2012) reported that in 12 *Woreda*s with beneficiaries of 171,583 became food insecure and were targeted for PSNP in the same year. in particular, .

Many studies have indicated that understanding the situation of food insecurity requires basic information at local and household levels in addition to national and regional levels (Riely *et al.,* 1999). In seemingly food self sufficient *woredas*, there are *kebeles*, households or at least individuals that suffer from food shortages. Therefore, this study has been intended to examine such situations at micro level which needs further investigation on its food insecurity status.

1.2 Statement of the Problem

Many studies conducted in Ethiopia have confirmed that there is insecurity in many parts of the country. The impacts have covered a large number of people though the causes of food insecurity differ from place to place. Among these, diminution in per capita land holding with increasing population growth, livestock availability, education status of household head, per capita income of the household from agricultural and nonagricultural activities, soil fertility, conflict, under-funded agriculture are the major and (Gebre-Selassie, 2005; Negatu, 2004; Ramakirshina *et al.,* 2002; Madeley, 2000 as cited by Frehiwot, 2007).

According to Hawassa Zuria *Woreda* Agriculture and Rural Development office report, 19 *Kebeles* encounter seasonal and chronic food insecurity every year, and have been targeted for PSNP since 2005 (HZWARDO, 2011). Much of the reviewed literature on household food insecurity has concentrated on describing qualitatively and quantitatively only on the status of household food insecurity; identifying the factors and examining their implications. It does not investigate the extent of food insecurity and models for food adequacy. Therefore, this study has tried to identify household food insecurity status, its extent and factors affecting food insecurity in the study area and provide information assist efforts of filling these gaps by answering the following key research questions:

i. What is the status of food insecurity in the Hawassa Zuria *Woreda*?
ii. What is the severity level of households' food insecurity in the Hawassa Zuria *Woreda*?
iii. What are the major determinants that affect the status food insecurity in the study area?
iv. What are the household coping strategies practiced in response to food shortages?

1.3 Objective of the Study

The general objective of this study is to examine the food insecurity status and identify factors influencing food insecurity level in rural households of Hawassa Zuria *Woreda* in Sidama Zone. The specific objectives of the study are to:

- to assess food insecurity status of rural households in Hawassa Zuria *woreda,*

- to assess severity of households food insecurity in the study area,
- to identify the determinants of household level food insecurity status of the rural households and
- to identify the coping mechanisms of the households to food shortages.

2. Literature Review

2.1 Concepts of Food Security and Insecurity

The concept of food security has broadened to include both the supply and demand sides of food security: supply, access, vulnerability and sustainability issues. There are many definitions which are valid and important in use by different agencies. Maxwell and Farankenberger define food security as

> *"A society which can be said to enjoy food security is not only one which has reached the food norm ….but which has also developed the internal structure that will enable to sustain the norm in the face of crises threatening to lower the achieved level of food consumption. The internal structure from the basis of the capacity to endure…or the capacity of a given system/unit to undergo perturbation without a decline in the degree of progresses made towards food norm." (*Maxwell and Farankenberger, 1992)

The most widely used definition of food security is the one given by the World Food Summit held in 1996 which says broadly.

> '*Food security exists when all people at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life'* (FAO, 1996).

This definition integrates stability, access to food, availability of nutritionally adequate food and the biological utilization of food.

Food insecurity, conversely, occurs when people do not have enough to eat according to accepted cultural norms due to various reasons: unavailability, lack of access and inadequate utilization of the required amount of food. The phrase '*Food Insecurity'* has been used to describe the instability of national or regional food supplies. Now food insecurity also includes lack of secure provisions of food at the household and individual levels. Household food insecurity is generally defined as inadequate physical availability of food supplies or income, poor access among households or members, and inadequate utilization of food (Habicht and *et al.*, 2004).

2.2 Indicators of Food Insecurity and Measurements

Indicators of food insecurity

According to Maxwell and Farankenberger (1992) there are ranges of indices developed to indicate food insecurity situation at international, national, regional, and district, household and individual levels. These ranges of indices are grouped into two broad categories: process and outcome indicators.

Process indices are further classified into supply and access indictors. **Supply indicators** indicate the food security situation of an area, at regional and national levels. Data and information on metrology, natural resource potential, agricultural production, pest prevention, market, and food balance sheet show food supply situation at national and local levels depending on the indices. The main weakness of supply indicators is that they do not show the situation of food security at household and individual levels. On the contrary, food insecurity situations such as famine and hunger can occur despite the availability of food (Maxwell and Farankenberger, 1992). On the other hand, **Access indicators** refer to socio-economic indicators that represent stress and household responses to the stress. The indicators are important in measuring food access and effective demand. There are many such indices on use to measure food security at different levels. Some of the familiar ones are sale of assets, change in land use practices, dietary change, diversification of income sources, change of food sources, reduction of consumption, and migration (Wiseman *et al.,* 2009 cited in Asferaw, 2012).

Outcome indices are the other broad category indicators used to measure the status of food security at a given point in time. Such indices include food consumption frequency, household budget and expenditure, subsistence potential ratio, nutritional assessment, storage estimate and household perceptions of food insecurity (Maxwell and Farankenberger, 1992; WFP, 2008). Some of the drawbacks of outcome indicators like anthropometrics (nutritional assessment) are that their results may not exactly indicate the level of food crisis. This is so because nutritional intake is affected by a number of factors such as health and sanitation (Maxwell and Wiebe, 1998 cited in Kifle, 2011).

Measurements of food insecurity

There is no defined and clear method to measure food insecurity due to its diversified feature and different levels of consideration. As indicated by Debebe (1995) it depends upon resource availability and time constraints, objective of the study, data availability, types of users and degree of the required accuracy. Mulugeta (2002) shows that food insecurity status can be measured in terms of food demand (requirement) and supply indicators at national level.. This refers to the quantities of available food compared to needs.

According to Hoddinott (2002) noted that there are four measures of household and individual food insecurity: Individual intake, household caloric acquisition, dietary diversity and coping indices. The following section presents a review of the merits and demerits of each method.

Individual intake: This is a measure of the amount of calories or nutrients consumed by individual in a given period of time usually 24 hours. For this measure there are two ways of data collection. An enumerator stays with the household for an entire day and measures the amount of food served to each person or use the previous 24 hours consumption for each household member. The advantage of using this method is that it produces, if correctly implemented, the most accurate measure of individual caloric intake (and other nutrients), hence, it is the most accurate measure of food insecurity status of an individual. It is also possible to determine whether food insecurity status differs within the household because the data is collected on an individual basis. The disadvantage of the method is that it requires highly skilled enumerators who can observe and measure quantities quickly and accurately (Hoddinott, 2002; Smith *et al.,* 2006).

Dietary diversity: One or more persons within a household are asked items they have consumed in a specific period. It is suspected that there may be differences in consumption among household members. But the simple form of this measure does not record quantities. If it is not possible to ask about frequency of consumption of particular quantities, it is not possible to know which diets are inadequate in terms of caloric availability (Hoddinott, 2002; Smith *et al.,* 2006)

Indices of household coping strategy: This is an index based on how households adopt to the availability or lack of food. The person within the household who has primary responsibility for preparing and serving meal is asked a series of questions regarding on how households respond to food shortages. This method is easy to train enumerators to ask questions, and, individuals generally find them easy to answer. Its disadvantage is that it does not capture consumption of particular quantities and hence it is not possible to estimate kilocalorie consumption per household.

Household calorie acquisition method: It measures the number of calories available to the household for consumption in a defined period of time. The amount and type of food consumed within 7 or 14 days by a household is collected through interviewing the person in household responsible to prepare food. The amount of calorie consumed by the household is computed by converting the amount consumed to kilocalorie and is compared to the national standard to know the food security status of the household (Hoddinott, 1999). Household calorie acquisition method is easy and yields better information as it solves some problems which reduce data quality in other methods. Because questionnaires are retrospective rather than prospective, the possibility for respondents to change their behavior is less. The level of skill required by enumerators is less than that of the information obtained from individual intakes. However, the method needs a large amount of data to be checked both at the field and during data processing (Hoddinott, 1999).

3. Research Methodology

3.1 Description of the Study Area

Geographically, Hawassa Zuria *Woreda* which is located at about 298 km to the south of Addis Ababa and at 27 km to the west of Hawassa, the capital city of SNNPR. It is divided into 23 rural and 3 urban *Kebeles* and covers a total area of 245.15 Km^2. The total population of the *Woreda* was 135,618, of which 68,395 were males and the remaining 67,223 were females. On average population density of Hawassa Zuria *Woreda* is estimated to be 553.2 persons per square kilometer. Of the total population, more than 97 percent were reported to live in rural areas (SZoFED, 2010).

3.2 Data Source, Sampling Procedure and Methods of Data Analysis

Both qualitative and quantitative data have been employed to identify the cross sectional problems of food insecurity. In order to capture a representative sample, a multi-stage sampling technique was used. In the first step, Hawassa Zuria Woreda was selected using a purposive sampling technique based on the greater number of people who are food insecure, which means 19 out of 23 rural Kebeles are food insecure, and personal experience of the researcher. In second stage, 4 *Kebele*s were selected by using a simple random sampling technique to represent the whole *woreda.* Finally, to give equal chance and be free from selection bias, a total of 192 respondents were selected from the respective list of farmers which is a complete list of households in each *Kebele* obtained from the *Woreda* Administration and offices of the 4 *kebeles* by using systematic sampling techniques.

This study has adopted a sample size determination formula provided by Yamane (1967), cited in Uilma (2005).

$$n = \frac{N}{1+N\,(e)^2}$$

Where:
n = is the sample size
N = is the population size
e = is the level of precision or the sampling error in this study (0.07).

$$n = \frac{3420}{1+3420\left(.07\right)^2} = 192$$

The probability proportional to size sampling technique was employed to decide the sample size for each *Kebele* Administration.

The analysis employed both descriptive statistics and econometric methods. Descriptive statistics such as mean, percentage, t-test and chi square test were employed to describe household characteristics with food insecurity status. Binary logistic model was specified and estimated to identify determinants of food insecurity. To measure individual effects of influential independent variables more precisely after logit marginal effect was utilized. Household Hunger Scale model was used for the computation of incidence and severity of food insecurity among sample households. Data analysis was conducted using STATA version 12.

3.4 Econometric model specification

Following Gujarati (1995), the functional form of logit model is specified as follows

$$P_i = E(Y = 1/x_i) = \frac{1}{1 + e^{-(\beta o + \beta i x i)}} \quad (1)$$

For ease of exposition, we write (1) as:

$$P_i = \frac{1}{1 + e^{-Zi}} \quad (2)$$

The probability that a given household is food insecure is expressed by (2) while, the probability for food secure is:-

$$1 - P_i = \frac{1}{1 + e^{Zi}} \quad (3)$$

Therefore we can write: $\frac{P_i}{1-P_i} = \frac{1/1+e^{-Zi}}{1/1+e^{Zi}} = \frac{1+e^{Zi}}{1+e^{-Zi}}$ (4)

Now $\frac{P_i}{1-P_i}$ is simply the odds ratio in favor of food insecurity. The ratio of the probability that a household is food insecure to the probability of that it is food secure.

Finally, taking the natural log of equation (4) we obtain:

$$L_i = \ln\frac{[1-P_i]}{[P_i]} = Z_i = B_o + B_1x_1 + B_2x_2 + \cdots + B_nx_n \qquad (5)$$

Where:

P1 = is a probability of being food insecure ranges from 0 to 1

Zi = is a function of n explanatory variables (x) which is also expressed as:

$$Z_i = B_o + B_1x_1 + B_2x_2 + \cdots + B_nx_n \qquad (6)$$

Where

B_o is an intercept

$B_1, B_2 .... B_n$ are slopes of the equation in the model.

L_i is log of the odds ratio=z_i

x_i is vector of relevant characteristics (independent variables).

If the disturbance term (Ui) is introduced, the logit model becomes

$$Z_i = B_o + B_1x_1 + B_2x_2 + \cdots + B_nx_n + U_i \qquad (7)$$

3.4.5 Variable selection and goodness of fit

3.4.5.1 Variable selection

In this study selected explanatory variables were used to estimate the logistic regression model to analyze the determinant factors of household food insecurity status. A logit model was fitted to estimate the effects of the hypothesized explanatory variables on the probabilities of being food insecure or not. To measure individual effects of influential independent variables more precisely after logit marginal effect, marginal effect to mean for continuous variable and discrete change of dummy from 0 to 1 for categorical variables were utilized.

The number of variables that would be included in the model should be of the minimum possible that will deliver optimum information. In this study the variable selection process begins with an individual analysis of each variable. A systematic relation or association between each predictor variable with the response variable was made before the final model was selected.

Upon the completion of individual analysis, predictor variables for the econometric analysis were selected with a condition that any variable whose individual test has a p-value less than 0.25 was considered as a candidate for the econometric model along with all variables of known socio-demographic or economic importance (Hosmer-Lemeshow, 1989).

3.4.5.2 Assessment of goodness-of-fit

The goodness-of-fit or calibration of a model measures how well the model describes or determines the response variable. Assessing goodness-of-fit involves investigating how close values predicted by the model are with that of observed values (Bewick et al., 2005 cited in Dereje, 2010).

Goodness of fit of the model can also be assessed by considering how well the model classifies the observed data or examine how "likely" the sample results actually are. Thus, it was given the estimates of model parameters (SPSS, 1994; STATA Manual, 2012). In this regard, a variety of statistical tests exists for determining the significance or goodness-of-fit of a logistic regression model. These include: Deviance; Pearson; Likelihood Ratio Test; Hosemer - Lemeshow Goodness-of-Fit Test; and Nagelkerke Pseudo R2.

Examination of the confusion matrix by modifying the threshold value whenever necessary will help analyze the overall performance of the model. The fit is considered to be good if the overall correct classification rate exceeds 50 percent. According to Collet (1991) the choice of a suitable threshold value is made either by identifying the value that minimizes the overall proportion of misclassification or by compromising between the minimization of the two misclassification probabilities, namely the probability of declaring an individual to be in group 0 (food secure) when it should be in group 1 (food insecure) and vice versa. The study used the default threshold cut value of 0.5 which was set by STATA 12.

3.4.6 Definition of variable

The dependent variable is food insecurity status of a rural household, which is dichotomous in the model. It was identified by comparing total kilocalorie consumed in a household per adult equivalent per day with a daily minimum requirement of 2,200 kcal and those getting 2,200 kcal and above are food secure (which take 0) and food insecure otherwise (whose value was 1).

3.4.6.2 Independent variables

1. Sex of household head (SEXHHH): According to Asferaw (2012) access to different resources and the role played in productive activities varies with sex due to high gender disparity in rural Ethiopia. Male headed households have better access to resources and are engaged more in productive roles than female that have triple roles: productive, reproductive and social roles. Therefore, gender is expected to affect household food insecurity either negatively or positively depending on the sex of the household head (HHH). In this study, female- headed households were expected to be more food insecure than male-headed households. A dummy variable was used to denote this variable, i.e. 1 if the household head is male headed and 0 otherwise.

2. Age of household head (AGHHH): It is measured in terms of year and in most rural area of Ethiopia HHH is the most responsible member of a household to contribute labor and knowledge for farm production. In this study, age of household head was used as a proxy indicator for experience of household head since he/she started farming. Younger household heads were expected to have relatively poorer experience of the socio-physical environments and farming than older household heads, and this effect would diminish in later stage. Therefore, households below age of 20 and above 64 were expected to be food insecure in the study.

3. Literacy Status of Household Head (EDuc): Education helps a household head to increase productivity, through promoting awareness on the possible advantages of modernizing agriculture and improve way and adoption of technological inputs and by diversifying household incomes such as by helping secure better employment opportunity in off-farm activities. Hence, a household head educational level measured in numbers of years of schooling was expected to have negative correlation with food insecurity of a household.

4. Family size of Household Head (FSIZE): It refers to the number of family members in the household, measured in number of members or AE. An increase in household size implies more mouths to be fed from the limited resources. Thus in this study, it is hypothesized that the family with relatively large number of dependent family members (high dependency ratio) negatively affects the household with food insecurity.

5. Participation in Extension Packages (EXTPACK): Local extension workers are supposed to provide choices to households so that farmers can tailor the package to their needs and capacity. Participation in extension packages in this study entails practicing all or at least most recommended technologies, agricultural inputs, agronomic and management practices to increase production and productivity of the households. The variable was treated as a dummy, where a value of 1 was given if the household participated in different extension packages and zero otherwise, and hypothesized that participation improves food security status of households.

6. Size of Cultivated Land (SIZECL): This variable stands for the amount of total land area cultivated measured in hectares. In this particular study, total cultivated land owned by a household is taken as a proxy indicator for farm size is an indicator of wealth and income and is expected to be associated with food security status. Because of this, it was hypothesized that farmers who have smaller farmland are more likely to be food insecure than those with larger land area due to the fact that there is a low possibility to produce more food.

7. Number of Oxen Owned by Household (NOXEN): An ox is the most important factor in the agricultural systems of rural Ethiopia. Even for those households with less land size it gives the opportunity to rent land. Therefore, households who own more oxen are able to cultivate and produce more land and produce more, and hence have better chances to be food secure than who possess none or fewer oxen .

8. Technology Adoption (TCAD): It refers to utilizing agricultural inputs like chemical fertilizers, improved seeds, pesticides and farm credit. Households who reported as non-users of all or at least any one of this package of technology were considered as non-adopters. Non-adoption will be expected to increase the likelihood of being food insecure through its effect on decreasing farming systems and eventually decreasing food availability and income. Therefore, technological adoption was hypothesized that it has a negative effect to food insecurity of households, so the score 1 is given if the household is a technological adopter and 0 otherwise.

9. Livestock Possession (TLU): It is the total livestock (cattle, equines, sheep, goat, and chicken) owned by a household heads measured in TLU. Livestock are an important source of wealth. They are sources of meat, milk, butter and cheese for direct consumption and income generating and so livestock contribute for food security. Thus, livestock owned was hypothesized to have a negative relation with food insecurity.

10. Farm Income (FINCOME): This variable is defined as the total annual income in Birr earned from crop and livestock production. The main sources of income for rural households in Hawassa Zuria *Woreda* are crops and animals. Income is vital to purchase agricultural inputs, hire labor, purchase food and non-food items and generally to utilize basic necessities for life. All these variables are good indicators of a household's food security. As farm income rises, households increase expenditure on food items. Therefore, in this study total farm income was hypothesized to be negatively correlated with household food insecurity.

11. Off-farm Income (OFFARMINPART): It is the total off-farm and/or non-farm income that is earned by a HHH which take 1, if the HHH participates on off-farm and /or non-farm activities and 0 otherwise. It provides cash to buy food and non-food items required for household members and improve their food security status. Hence off- farm income was expected to have a negative correlation to food insecurity and takes 1 if the HHH participates in off-farm activities and 0 otherwise.

12. Access to Credit (ACC Credit): It is a dummy variable in the regression model. In the study area, micro-finance institutions, the government through cooperatives and money lenders provide credit services. Access to credit services from different sources was tested in this model and expected to have a negative correlation with food insecurity for many reasons. Consumption smoothing, creating productive assets, access to finance to purchase agricultural inputs are important credit services in improving food security status, so it takes 1 if the household have access to credit services and 0 otherwise.

13. Attending training at FTC: Farmers Training Centers (FTCs) are key institutions to train farmers and transfer improved agricultural technologies and bring adequate services closer to them. In the study it refers to farmers' attendance of modular training in the FTC and takes 1 when the households attend training and 0 otherwise. Therefore, attending training was hypothesized to have a negative correlation with household food insecurity.

4. Results and Discussion

4.1 Food Insecurity Status in the Hawassa Zuria Woreda

According to the result of this study it was found out that119 (62 percent) of households were food secure and the remaining 73 (38. percent) were food insecure. The amount of calorie consumed per AE varies from 927.17kcal / day /AE from food insecure category to 5197.64 kcal in food secure category (Table 4.1). The average energy consumption of the sample was 2505.764 kcal/day/AE, which is above both the recommended daily allowance (2200kcal) and the average consumption of SNNP region, 2058kcal (CSA, 2007).

Table 4.1: Food insecurity status of the Hawasaa Zuria *Woreda*

Household food security Status	Frequency	Percentage	Mean	Minimum	Maximum	Standard deviation
Food Secure	119	62	3106.94	2210.25	5197.64	630.43
Food Insecure	73	38	1525.75	927.17	2187.60	349.31
Overall	192	100	2505.74	927.17	5187.64	940.09

Source: Own survey, (2013)

The Household Hunger Scale measures the severity level of food insecurity in the study area. Accordingly, 69; 25 and 6 percent of respondents reported little to no hunger, moderate hunger and severe hunger in the households, respectively (Table 4.3).

Table 4.2: Severity of households hunger in the Hawassa Zuria Woreda

Household Hunger Scale category	Percent
Little to no hunger in the household	69
Moderate hunger in the household	25
Sever hunger in the household	6
Total	100

Source: Own survey, (2013)

4.2 Causes of Household Food Insecurity

In the study area households reported that shortage of land (32.85 %), land degradation (27.74%), large family size (24.09 %) and erratic rainfall distribution (15.33 % are the major causes for household food shortage. Specifically, 93.05 percent of the food insecure households reported that land shortage, land degradation and large family size are the major causes for food insecurity. (Table 4.3)

Table: 4.3: Causes of Food Shortage

Causes of Food Shortage	Food Security Status of Households						Chi-square
	Food Secure		Food Insecure		Total		
	N=119	%=62	N=73	%=38	N=192	%=100	
Large family size	15	45.45	18	54.55	33	24.09	
Erratic rainfall distribution	16	76.19	5	23.81	21	15.33	8.8**
Shortage of land size	17	37.78	28	62.22	45	32.85	
Land degradation	17	44.74	21	55.26	38	27.74	
Total	64	47.45	72	52.55	137	100	

Source: Own survey, (2013)
*** Significant at 5% significance level

Many studies in Ethiopia also indicate that land degradation and small agricultural land size are the major causes of low and in many places declining agricultural productivity, and the continuing of food insecurity and rural poverty in the country (Shiferaw and Holden, 1998; IFPRI, 2005). In the same fashion, HZWAO (2011) indicated that the average land holding of farmers in the Hawassa Zuria *Woreda* is less than 0.5 hectare, and even this is exposed to heavy erosion and continuous cultivation. As a result, land productivity is decreasing making it a major cause of food insecurity in the *Woreda*. The result from focus group discussion consistently confirmed that large family size, small cultivated land size and high price for agricultural inputs were the major causes for food insecurity in the *Woreda.*

4.3 Households Coping Mechanisms

Households use different coping mechanisms when they face food insecurity. The most common copying strategies employed by households include at the initial stage: intercropping (87.5%), engaging daily labor (74.5%), participating in petty trading (45.8%),sending children to the labor market (21.9%), selling livestock (chicken, sheep and goat) (16.7%); and using irrigation(11.4%).Similarly during the severe stage of food stress HHs employed selling livestock 89.5%,reducing amount of meals (78.6 %), selling household assets (58.3%), migration to the nearby towns (51.04%), engaging in different food security programs (45.8%) and sending children to the labor market (42%).

On the other hand, the result from FGD revealed that household heads often migrate to the nearby town (Hawassa) to search for better jobs, send wives to serve is better-off houses as housemaids and to receive in addition to salaries daily consumption of food items as well as force children to quite school and assign them to herd the cattle of better-off families..

4.5 Descriptive Analysis

In this part the summary of discrete and continuous variable in relation to food insecurity status will presented. The result showed that there is no statistical difference with the sex of the HHH and food insecurity status of households. However, among the discrete variables, there is a visible difference between food secure (FS) and food insecure (FI) proportion of households with respect to the literacy status of the household head, technology adoption, off-farm participation, attending training at FTC and participation in extension programmes (Table 4.4).

Table: 4.4.Descriptive statistics for categorical variables

Variables	Description	Food insecurity status		Total	Ch-square
		Food S	Food In		
Sex of HHH	Female	55.32	44.68	24.48	1.17 ns
	Male	64.14	35.86	75.12	
Literacy status of HHH	Literate	80.67	12.33	54.17	29.29 ***
	Illiterate	19.33	87.67	45.83	
Technology Adoption	Adopter	76.32	23.68	79.17	78 ***
	Non-Adopter	7.5	92.5	20.83	
Off-farm participation	Participant	68.75	31.29	84.90	20.75 ***
	Non-participant	24.14	75.86	15.10	
Access to credit	Yes	91.89	8.11	38.54	45.01 ***
	No	43.22	56.79	61.46	
Training at FTC	Attended	7.52	22.48	67.19	40.3 ***
	Not-Attend	30.16	69.84	32.81	
Participation in Extension	Participate	72.08	27.92	80.21	89 ***
	Non-participant	21.05	78.95	19.79	

Source: Own survey, (2013)

Ns-Not significant

*** Significant at <1% significance level

Analysis of continuous variables showed that family size, cultivated land size in hectare, livestock possession in TLU, oxen ownership and farm income were significant at less than 1% probability levels for the food secure and insecure households. But there was no significant difference between food secure and insecure categories in terms of age of the household head (Table 4.5).

Table 4.5: Descriptive statistics for continuous variables

Variables	Food insecurity status of HH				
	FS(mean)	FI(mean)	Min/Max	Mean	t-test
Age of HHH (year)	40	43	22/68	41	-1.9ns
FSIZE (AE)	5.1	6.4	2/10	5.5	5.49**
CLAND (in hectare)	0.6	0.3	0.12/4.5	0.5	5.49**
Livestock					
possession(TLU)	5.3	2	0/12	4	10.62***
Oxen owned	2	0.56	0/5	1.51	9.34***
FINCOME(in birr)	3121	1091	0/6800	2448	72***

Source: Own survey, (2013)
Ns-Not significant
*** Significant at <1% significance level

4.6 Econometric Result

Before fitting the logit model, it is essential to check whether there is or not a high degree of association among and between the continuous and discrete explanatory variables which might produce incorrect results. To check the same, variance inflation factor (VIF) and contingency coefficient were used for continuous and discrete variables, respectively. The computational results of the variance inflation factor for continuous variables confirmed the non- existence of association between the variables. As a result, all the six explanatory variables were retained and entered into logistic analysis (Appendix Table 1). Similarly the results of the contingency coefficient reveal that there was no serious problem of association among discrete explanatory variables (Appendix Table 2). Hence, all the five discrete variables were entered into logistic analysis.

Among these predictor variables which have statistically significant association with food insecurity status of households, and examined for individual marginal effect after logistic regression, family size of household, cultivated land size, tropical livestock, and participation of extension package, access to credit, farm income and educational status of household head were selected by the model (Table 4.6).

4.6.1 Model adequacy checking

The various goodness of-fit measures validate that the model fits the data well. The value of Wald Chi-square test shows the overall goodness-of-fit of the model at less than 1 percent probability level. Additionally, goodness-of-fit in logistic regression analysis is measured by pseudo R^2, which works on the principle that if the predicted probability of the event is greater than 0.5, the event will occur, otherwise not. The model result showed the correctly predicted percent of sample household is 77.2 percent, which is greater than 0.50.

With regard to the predictive efficiency of the model, out of 192 sample households included in the model, 181 (94.27 percent) were correctly predicted. The sensitivity and specificity indicate that 94.52 percent of food insecure and 94.12 percent of food secure households were correctly predicted in their respective categories. With regard to the error rates committed in the classification table, the false positive rate (the number of errors where the household is predicted to be food insecure, but is in fact food secure) is 9.21 percent while the false negative rate (the number of errors where the household is predicted to be food secure, but is in fact food insecure) is 3.45 percent. This result is thought to provide evidence that the model fits (Appendix Table 3).

4.6.2 Factors Affecting Food Insecurity Status of Households

Among the 13 independent variables considered in the logit model, 7 variables were found to have a significant impact on the status of food insecurity. Family size was significant at 1 percent probability level and positively associated with the state of food insecurity. This positive relationship shows that the probability of being food insecure increases with increase in household size. Other things remaining constant, as family size increased by one AE, the probability of household being food insecure increase by 14 percent. The possible explanation can be those households with many children; more mouths to be fed from the limited resources could face food insecurity because of a high dependency burden.

The model result reveals that size of cultivated land has significance at 1 percent level and negatively influence the food insecurity status of the household in the study area. The implication is that the probabilities of being food insecure decreases with farm size. Negative marginal coefficient of 0.69 for this variable implies that, other things kept constant, as farm land size increases by one hectare the probability of a household being food insecure decreased by 69 percent. The rational beyond this is that smaller farms are associated with lesser wealth and income and decreases availability of capital, which decreases the probability of investment in purchase of farm inputs that leads to less food production and food insecurity.

Herd size is negatively related at five percent significance level to the food insecurity in the Hawassa Zuria *Woreda*. The negative relationship is explained by the fact that herd size is being used a proxy for a farmer’s resource endowment and those sample farmers with small herd size have less chance of earning more income from livestock production. In addition to their use as a source of food, animals are important in stabilizing food access during food shortage seasons. Farm households possessing milking cows got direct access to milk, cheese, butter and meat. Indirectly, livestock are important sources of income and are draught power for crop production and cow dung for improving soil fertility. The negative marginal coefficient of 0.042 for TLU implies that as livestock possession increased by one TLU, the probability that households being food insecure decreased by 4.2 percent.

In the study area households participated in different extension packages like crop production, animal husbandry, horticulture and natural resource management and it is significant at 10 percent probability level and negatively associated with the state of food insecurity .The negative sign is an indicator of its influence in affecting food insecurity. The possible explanation is that those farmers who have no access to participate are more likely to be food insecure than those who have access to it. The negative marginal coefficient of 0.48 for this variable indicates that, holding other variables constant, a shift to participation in extension package decreases the probability of household food insecurity by 48 percent.

The results of the survey revealed that access to credit is negatively related and significant at less than 10 percent probability level with food insecurity. Holding other things constant, the probability of a household being food insecure decreases by 15 percent as it has access to credit. The possible explanation is that credit gives the household an opportunity to be involved in income generating activities so that derived revenue increases financial capacity and purchasing power of the household to escape from the risk of food insecurity. Access to credit also smoothens consumption when household faces hard times.

Farm income is found to have a negative impact and significant at 1 percent probability level on the probability of being food insecure. The result of this study supports the hypothesis that a larger income has a positive impact on the probability of being food secure. The possible explanation is that, in the study area, households who managed to earn more farm income had a very low chance of being food insecure than those who had not. In other words, a larger annual income may also affect the probability of being food in secure by providing a source of cash flow to offset the risk associated with crop failure due to bad weather condition. The interpretation of the coefficient implies that, if other factors are held constant, the probability of being food insecure decreases by 57 percent as the farmers get unit of income.

Educational level of the household head had a negative association with food insecurity status and statistically significant at 10 percent level of significance. The negative marginal coefficient implies that holding other variables constant, shifting from being illiterate to that of being literate reduces the probability of households being food insecure by 22 percent. It is explained in terms of the contribution of education on working efficiency, competency, and diversification income, adopting new technologies generated from research centers, getting knowledge and information from development agents, communicating and protecting the right to get access to resources and becoming visionary in creating a conducive environment to educate dependants. Thus, being literate reduced the chances of becoming food insecure in the sample households.

Table 4.6: Factors affecting food insecurity status of households

Variable	Coefficient	Robust std.Err	Z	Marginal effect(dy/dx)	X
SEXHHH•	-0.865	0.737	1.17	-0.125	.76
AGEHH	-0.0414	0.052	-0.79	-0.005	41.34
FSIZE	1.141	0.390	2.92 ***	0.141	5.59
CLAND	-5.567	1.896	-2.94***	-0.686	0.50
TLU	-0.341	0.187	-1.82**	-0.042	4.07
EXTPACK•	-2.736	1.362	-2.01 **	-0.479	0.73
FTCATT•	-0.825	0.989	-0.83	-0.113	0.67
ACCCredit•	-1.373	0.622	-2.21 *	-0.154	0.39
OFFARMINPART•	-.223	1.061	-0.21	-0.029	0.85
FINCOME	-4.451	0.895	-1.83***	-0.575	2269.44
NOXEN	-0.378	0.434	-0.87	-0.021	1.51
Educ•	-1.627	0.728	-2.23 *	-0.216	0.55
TECHADOPTION•	-2.242	1.161	-1.93	-0.391	0.76
_Cons	4.272	1.882	2.27		
Number of observation	192				
Wald (chi^2 (11)	49.62				
Prob>Ch^2	0.0000				
PseudoR^2	0.7721				
Log pseudo likelihood	29.057982				
Sensitivity Pr (+| D)	94.52%				
Specificity Pr (-|~D)	94.12%				

Source: Own survey, (2013)

*, **, *** Significant at less than 10%, 5% and 1 % probability level

• dy/dx is for discrete change of dummy variable from 0 to 1

5. Conclusion and Recommendations

5.1 Conclusion

Food insecurity in the long run may cause irreparable damage to livelihoods of the poor, thereby reducing self-sufficiency. This study was carried out to contribute to the reduction of food insecurity initiatives and rural livelihoods development by availing information on the food insecurity situation, its determinant factors and local coping strategies in Hawassa Zuria *Woreda.*

The research objectives were realized through conducting a household survey in four administrative *Kebeles* in the study area. A total of 192 household heads were selected randomly through a systematic random sampling method. To this end, investigation of the bio-physical, demographic and socioeconomic characteristics of food secure and food insecure groups of households was made. Identification and examination of major causes of food insecurity and measuring the incidence of food insecurity of food insecure households as well as assessment and analysis of the local coping strategies of the households in the *Woreda* were made. The sample households were classified into food secure and food insecure groups based on calorie acquisition value of meeting recommended daily allowance of 2200 kcal.

The analysis employed both descriptive statistics and econometric methods. Descriptive statistics were employed to describe household characteristics with food insecurity status. Binary logistic model was specified and estimated to identify determinants of food insecurity. A Household Hunger Scale model was used for the computation of incidence and severity of food insecurity among sample households.

The descriptive statistics showed that out of total sample households 62 percent and 38 percent were categorized as food secure and insecure, respectively. According to HHS model 69; 25 and 6 percent respondents fell into little to no hunger, moderate hunger and sever hunger households respectively.

Binary logit econometric model was employed to identify determinants of the probability of being food insecure as a function of various household characteristics The result revealed that seven out of thirteen variables, namely household size, cultivated land size in hectare, animal resources holdings measured in TLU, participation in extension packages, access to credit service, farm income and literacy status of a household head were found to be statistically significant with the hypothesized sign as determinant factors of household food insecurity in the study area.

Generally, the binary logistic regression analysis indicated that there was a negative and statistically significant relationship between the variables such as cultivated land size, animal resources holdings, participation in extension packages, access to credit service, and farm income and literacy status of a household head, and food insecurity in the study area. However, it was found that family size was positively and significantly associated with household's food insecurity status.

5.2 Recommendations

Understanding the causes and level of food insecurity would help policy makers design and implement more effective policies and programs for the poor, and thereby promote the improvement of food security. Based on the findings of the study, the following recommendations are made to reduce the food insecurity status at household level in the Hawassa Zuria *Woreda*.

1. Cultivated land holding was found to have a negative and strong correlation with food insecurity implying that increasing cultivated land size decreases food the insecurity situation. Land being a scarce resource, increasing cultivable land is not feasible. But, in addition to resettlement programs, soil and water conservation activities on degraded farm lands can help increase cultivated land productivity.
2. Family size was found to be directly and strongly related with household food insecurity. As indicated in the study, households with large family size are more likely to fall into food insecurity situation easily than those who have a small family size. Hence, awareness creation on the impacts of population growth at the family, community and national levels and provision of family planning services should be strongly promoted to reduce fertility and lengthen birth spacing. In this reared, Hawassa Zuria *Woreda* health office especially health extension workers can play an effective role in the area.
3. Farm income was found to have a negative correlation with food insecurity. Particular interventions have to be taken to increase farm income in the area through intensification of agriculture, increasing market access, increasing the productivity of major crops through the use of modern farm inputs such as fertilizers, improved seeds, pesticides, accessing irrigation facilities and post-harvest management that would help to address food insecurity.
4. Access to credit can create an opportunity to be involved in economic activity that generates revenue to households. In the study area, households who have no access to credit services are highly exposed to food insecurity than their counterparts. Appropriate interventions such as timely delivery of inputs and long term credit service facilitation are mandatory to raise level of technology use by smallholders.

5. Livestock holding was found to be significant with a negative coefficient implying that additional units of livestock reduces household's chance of being food insecure. However, productivity of livestock in the study area was found to be too low due to shortage of feed and poor management practices. Hence, necessary efforts should be made to improve the production and productivity of livestock, and this can be achieved through developing, promoting and introducing appropriate livestock production packages that are feasible in the area.
6. Education is a critical instrument in any development agenda. It helps households to increase productivity by promoting awareness on the possible advantages of modernizing agriculture through the adoption of technological inputs. It also diversifies household incomes by availing better employment opportunities in off- farm activities. Therefore, strengthening both formal and informal education and vocational or skill training should be promoted to support efforts of uprooting food insecurity.

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Appendix Table 1: Variance inflation factor for continuous variables

Continuous variables	VIF	1/vif
NOXEN	3.27	0.305852
TLU	3.19	0.313238
CLAND	1.54	0.649800
FINCOME	1.51	0.661619
FSIZE	1.45	0.689243
AGEHHH	1.34	0.745201
Mean VIF	2.05	

Source: Own computation, (2013)

Appendix Table 2: Contingency Coefficients for dummy Explanatory Variables

	SEXHHH	TECHAD~N	EXTPACK	FTCATT	ACCCredit	Educ
SEXHHH	1.0000					
TECHADOPTION	0.0210	1.0000				
EXTPACK	0.0619	0.4190	1.0000			
FTCATT	0.0407	0.3094	0.4228	1.0000		
ACCCredit	0.0277	0.2941	0.3863	0.4167	1.0000	
Educ	0.1874	0.4186	0.4812	0.2998	0.4629	0.2589

Source: Own computation, (2013)

Appendix Table 3: Classification table of the model

Classified	True/Predicted		Total
	Food insecure	Food secure	
Food insecure(+)	69	7	76
Food secure(-)	4	112	116
Total	73	119	192
Sensitivity Pr (+| D)		94.52%	
Specificity Pr (-|~D)		94.12%	
Positive predictive value Pr (D| +)		90.79%	
Negative predictive value Pr (~D| -)		96.55%	
False + rate for true ~D Pr (+|~D)		5.88%	
False - rate for true D Pr (-| D)		5.48%	
False + rate for classified + Pr (~D| +)		9.21%	
False - rate for classified - Pr (D| -)		3.45%	
Correctly classified		94.27%	

Source: Own computation, (2013)

DETERMINANTS OF OFF FARM EMPLOYMENT: A Case of Abeshge Woreda, Guraga Zone, Ethiopia

Mezid Nasir[1]

Abstract

The aim of this study is to identify the demographic and socioeconomic factors that determine off farm participation of households using cross sectional surveying data. The data used for this study was collected from four rural kebeles of farm households with the total sample size of 221, and individual household heads were selected by applying a multi stage sampling technique. Kebeles are selected purposively based on relative location in nearby towns as well as the type of crops produced, while households are selected randomly from the stratified sample frame. In order to meet the objective of the study, ordered logistic regression model was applied. The results from the ordered logistic regression model show that off farm participation of farm households is driven by push factors and seasonal variation in farm activities. Therefore, the government should intervene in the rural labor market in order to improve the livelihood of rural poor farm households.

Key word: Off farm employment, rural households, ordered logit, Abeshge, Ethiopia

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1. Introduction

Off-farm activities could be classified as wage employment (including cash or food for work) or self-employment. In the last decade, most research has given attention to rural nonfarm employment, because growth in agriculture remains to be insufficient to solve rural poverty without others source of rural growth (Lanjouw et. al, 2000). In spite of the high potential of the non-farm sector in generating employment, it is not included in policies and strategies of the Ethiopia in government. (Beyene, 2008). Most developing countries incorporate rural nonfarm employment as a core rural development strategy in poverty reduction because shrinking farm size, declining soil fertility and consolidation in the agricultural sector cannot be successful without a non-farm sector that provides gainful fulltime and part-time employment for the growing rural population (*Mulat et.al 2006; Otsuka et.al, 2008).*

Empirical studies show that non-farm sources contribute 40-5 0 percent of average income for rural areas of Africa. According to Davis cited in Zarai *et.al* (2010), in Ethiopia, 20 percent of the rural income originated from nonfarm source. The main type of business activities in the rural areas are trading, weaving, tailoring, basketry, blacksmithing, pottery, selling food and drinks as well as selling firewood, charcoal and wood for construction. Returns from these activities are generally low due to less purchasing power of the rural community and low level of urbanization in the country *(Mulat et.al 2006).*

Land scarcity and increasing fragmentation of already very small farms implies that the non-farm sector has to be developed to absorb more of the growing population. The policy to promote use of credit to stimulate adoption of high yielding varieties and fertilizer use has not been very successful in the fragile and drought-prone Ethiopian highlands. Hence policy makers have been looking for alternative development strategies for these areas and the development of non-farm income opportunities may be an alternative strategy (Holder et.al, 2004).

In rural areas some households participate in non-farm activities to gain advantages while others are pushed to non-farm employment because of lack of opportunities in farming (Davis, 2003). Consequently, identifying which factor (push or pull) determines off farm participation is important for policy makers may require different policy responses. Moreover, studies on the off-farm participation decision of Ethiopian farm households are limited (Beyene, 2008). Therefore, this study which attempts to find out the determinants of-off farm participation of farm households and the rate of their participation, is expected to add to the literature on determinants of off- farm participation

The objectives of the paper are to (1) identify factors that affect off-farm participation decision (2) understand the implication of off-farm employment on intensification versus poverty reduction. Data was collected from four sub-districts of Southern nations, nationalities and Peoples of Ethiopia, specifically the Gurage Zone. The data was collected through a questionnaire from 221 farm household heads. It includes individual and household characteristics, resource endowment and off-farm labor supply, which disaggregates into different types of off-farm activities. Ordered logistic regression model is used in order to identify the determinants of off-farm employment.

The rest of the paper is organized as follows. Characteristics of off- farm employment in the study area are described in section 2, followed by a revision of theoretical and empirical literatures on off-farm employment. In section 4 model specification and estimation are described, followed by section 5 dealing with estimation results and discussion. Finally, provides conclusions and policy recommendations.

2. Data Source and Characteristics Off Farm Employment

A questionnaire based survey is conducted in four selected sub-districts, namely *Mamedie, Michile and Tereqo, Tawula & Gefersa* and *Gihbebare* sub- districts located in the west, north east, south west and south west of Welkite town, respectively. Gihbebare was selected because it is found far from Welkite town and a large agricultural investment was undertaken and the majority of households participated in off- farm activities. Mamedie and, Michile and Tereqo districts were selected since they, in addition to cereal crops, produce permanent (perennial) crops. In Mamedie sub district, particularly perennial crop production is dominant, which includes Enset, coffee, Chat, mango and avocado. The production time for cereal and permanent crops are slightly different, and as a result the effect on off- farm employment participation may not be the same across the sub district.

From multi-stage sampling, 221 farm households are chosen randomly. In the first stage, strata were made based on the relative location of the sub-districts (Kebeles) from urban centers as well as the type of crop produced. Based on this framework, two districts nearby towns and two districts far from urban centers, with a total of four sub-districts are purposively selected. In the second stage, in order to select household from each sub-district the households heads are stratified based on the total land he/she ownes in selected sub districts.

Finally, from each district with a proportionate sample size in each stratum, households are selected randomly from each sub district. Hence, to select four sub districts, land holding, location and form of crop production variation are considered. The survey data provides detailed information on seasonal labor allocation (for farm and off-farm activities for each plot), type of off-farm employment activities and income sources (annual and permanent crops, livestock, wage employment, off-farm employment), purchase of farm inputs (fertilizer, local and improved seed for each crop, pesticide, farm machinery and hired labor), individual characteristics of the household head and household compositions. Furthermore, data on accessibility to infrastructure, credit and wage of skilled and unskilled labor was collected. The data used for this study was collected from rural households for the period of agricultural production and harvesting seasons of 2012/2013.

The data set characterizing the households is given in Table 1. Of the total sample of surveyed households 3.6 percent are female and the remaining 96.4 percent are male headed. This figure does not indicate that the number of women in the study area small, rather it shows that women are not nominated as head or do not decide on critical issues, since the culture does not courage to do so, although they run home operation (activities) and cover all expenditure of household members. With regards to marital status, about 85 percent of households are married and the remaining 15 percent are divorced, widowed and single. With respect to educational attainment, 28.1 percent of sample respondents are illiterate, while 51.1, 14, 2.3 and 4.5 percent are attending primary, secondary, certificate and diploma level of schooling, respectively. On the average, the family size is 5.1, which is somewhat similar to the national average (5.0). The average dependency ratio (number of dependants over family size) is computed to be 100 percent. Except one respondent who was more than 64 years old, the remaining dependents were less than 15 years old. In other words, there is a one to one correspondence between the ages of below 15 and above 15 years of the sample survey household population, while the mean age of the head is 39.2 years.

Table 1: descriptions of farm household demographic characteristic

Variable	Mean	Std. Dev.	Min	Max
Percent of male headed households	96.38	-	-	-
Percent of female headed households	3.62	-	-	-
Percent of married households	85.07	-	-	-
Percent of (single, divorced and widowed) HH	14.93	-	-	-
Percent of Orthodox households	55.66	-	-	-
Percent of Muslim households	43.44	-	-	-
Percent of Protestant households	0.90	-	-	-
Percent of illiterate households	27.60	-	-	-
Percent of primary educated household heads	51.58	-	-	-
Percent of above secondary educated household heads	20.81	-	-	
Age of household heads	39.25	9.05	17	70
Family size	5.05	2.12	1	12
Non working days	74.38	38.71	0	209
Dependent household members	2.43	1.70	0	7

Source: Own survey 2013

Farm households commonly involve in wage employment and self-employment (own business activities). Wage employment includes paid farm work, professional activities (Teaching other government activities), and skilled labor (manual work in construction, masonry, carpentry). Self-employment includes petty trading (brewing local alcohol and food, grain trading), fuel wood selling, charcoal making and unskilled non-farm work (weaving, handicrafts and milling). Eighty one out of two hundred twenty one household heads or about 36.7 percent of farm household heads participate in off-farm activities, while at least one member of 38 percent or eighty four farm households participate in off-farm employment. Most of the households participate in self employment activities which do not require any professional qualification except masonry and carpentry. Participation of households in off-farm self employment is 54.7 percent, in petty trading 58.7 percent, in skilled labor, 24.1 percent while unskilled non-farm work stands at 13 percent. Selling firewood and account for charcoal 4.3 percent. The proportion of households that participate in off-farm wage employment is 45.3 percent. Paid farm workers take the highest share of off- farm wage employment at 47.4 percent followed by professional activity at 39.5 percent. In general, petty trading is the dominant type of off-farm employment with 31.8 percent, followed by paid farm work at 21.2 percent.

Table 2: Farm household participation in off farm employment

Types of off farm activities	Participation rate (%)	Cumulative participation rate (%)
Farm worker	21.4	21.4
Professional	17.9	39.3
Driver	1.2	40.5
Guard	4.8	45.3
Off- farm wage employment	45.3	-
Petty trading	32.1	77.4
Selling firewood and charcoal	2.4	79.8
Unskilled non-farm worker	7.1	86.9
Skilled labor	13.1	100
Off- farm self employment	54.7	-
Overall participation in off-farm	38.0	-

Source own survey 2013

On average, (83.3) days or (665.6) hours' of labor is supplies to the off farm employment, and the proportion of family labor supply to off-farm employment is 44.3 percent. Labor supply to off- farm employment is the highest at 35 percent during the slack season (plowing period) and the lowest at 32 percent occur during planting and weeding times. On the other hand, most of the hiring of labor is done during the planting and weeding season, and the percentage of labor-hiring is lowest during the slack seasons.

The study shows that the share of off-farm income in the rural areas range from 30 to 50 percent of farm households' total income (Davies, 2002). However, the share of off- farm income for the farm household is (16.2%) in survey area which is slightly lower than the national level of 20 percent cited in (Zarai et.al, 2010). The income obtained from off-farm employment is spent on consumption.

Table 3: Family off farm labor supply

Variables	Mean	Std. Dev.	Min	Max
Off farm labor supply of households	83.27	128.53	0	540
Income generates from off farm employment	4224.3	12636.53	0	156000
Percent of off farm labor supply to family labor	44.3	-	0	-
Percent of off farm labor supply for planting	32.2	-	0	-
Percent of off farm labor supply during plowing	34.7	-	0	-
Percent of off farm labor supply during harvesting	33.2	-	0	-
Percent share of off farm income to total farm income	16.2	-	0	-

Source own survey, 2013

The lion's share, which is close to 63.4 percent is spread out to smooth consumption, while farm inputs account for 14.6 percent and the marginal saving rate is 12.2 percent of off-farm income. This may indicate that off-farm employment is important to improve welfare, since welfare is more likely to be improved through consumption. Consequently, it has a positive effect on poverty alleviation of rural poor households via labor market channel. Therefore, off-farm employment has a positive effect on poverty alleviation rather than intensification or technology utilization.

Studies indicate that education is a concern in-off farm participation decision of farm households, because of which education status of farm households categorized into illiterate, primary, secondary, certificate and diploma and above. From the total farm households who participate in off-farm employment, illiterate, primary and secondary and above comprise 24.7, 43.2 and 32.1 percent, respectively. These figures indicate that there is no linear relationship between off- farm participation and educational attainment status of farm households. Some research shows that the educational status of farm household heads and off-farm participation decision have a significant relationship, and the results from chi2 statistic prove this fact. The chi2 test statistic suggests that there is a statistically significant relationship between ordinal off-farm participation and educational status of household head (p = 0.000). Meanwhile, when the education categories changed into two dummies (primary and, secondary and above) with the reference category of illiterate household head, the chi2 result shows that primary education has no statistically significant relationship to ordinal off-farm participation(p=0. 149), while secondary education has a significant relationship to ordinal off-farm participation of households. Therefore the relationship between off- farm employment and education status of households is not conclusive.

Table 4: Result from chi2 test statistic for the relationship between off farm participation and educational status of households

Ordinal off farm participation	Educational status of household heads					
	Illiterate	Primary	Secondary	Certificate	Diploma	Total
Low	41	79	18	2	0	140
Medium	8	9	6	0	0	23
High	12	26	7	3	10	58
Total	61	114	31	5	10	221

Pearson chi2 (8) = 37.3241 Pr = 0.000

With regard to landholding, the data indicates that there is an egalitarian type of land distribution allows close to 89 percent of farmers to have usufruct right of land. The land tenure system does not allow farm households to sell their land. Nevertheless, farms can lease out land. A few farmers, 6.5 percent of the households, do not cultivate their own plots. The size of land holding is very small and the land is divided into many plots. The average land holding and land cultivated figure per household are 1.93 and 1.77 hectares, respectively.

Of the total surveyed households only 24 (10.9) percent do not have their own land and among these farm households 18 of them (75) percent participated in off-farm employment and 88.9 percent of them were categorized as high participants. On the other hand, households who have their own land and participate in off-farm employment cop rise 32 percent. It is clearly observable that a large proportion of the landowners are participating in off farm employment.

The chi2 test result shows that there is a significant relationship between a land title holder and non holder in participating in off-farm activities. Therefore, land ownership matters in the off farm participation decision of households.

Table 5: The relationship between off farm participation and land ownership

Off farm participation level	Land ownership status		Total
	No	Yes	
None participant	2.7	60.6	63.3
Medium participant	0.9	9.5	10.4
High participant	7.3	19	26.3
Total	10.9	89.1	100

Farmers in the rural area participated in off-farm activities either as a result of push factors (inadequacy of land, liquidity constraint and surplus labor in the family) or pull factors (higher skill and experience, education, and attractive return). Most of the farm households, i.e. 52.4 percent participated in off-farm employment because of inadequacy of land and 27.4 percent to purchase farm inputs such as fertilizer.

In contrast, some 8.3 percent of households participate in off-farm activities because they find it more profitable than farm work. These the figures indicate that the majority of farm households participate in off- farm activities as a result of push factors.

48.2 percent of households do not participate in off- farm employment because of busy with farming activities. This may indicate that in rural areas there is no surplus labor supply to the off farm labor market. Hence, we can Premises that off farm labor supply cannot expand without reducing the amount of labor available for agricultural activities. On the other hand, only 5.1 percent of farm households hindered from participating off farm activities because of lack of skill and experience. This indicates the importance of education and training to participate in rural off-farm employment.

Table 6: Reasons for participation in off farm employment

Reason for participating in off farm employment	Percent of farm households
Land inadequacy	52.4
To purchase farm inputs	27.4
High return	8.3
Surplus labor in the households	2.4
Other	8.3

Source: own survey 2013

3 Literature Review

The terms "off-farm", "non-farm", "nonagricultural", "nontraditional", etc. normally appear in seemingly synonymous ways. The basic distinctions among activities and incomes are to be made along sectoral and spatial lines (Barrett et al, 2001). According to Haggblade et al. (2007) off-farm income or employment means off the owner's own farm that includes wage employment in agriculture earned on other people's farms along with non-farm earnings from the owner's non-farm enterprises or from non-farm wage earnings. Thus, off-farm income is the sum of rural non-farm income and wage earnings in agriculture. On the other hand, non-farm employment refers to all income-generating activities except crop and livestock production and fishing and hunting, located in areas that are mainly servicing agricultural activities (Barrett et al, 2001, and Lanjouw and Lanjouw, 2001). In most literature off-farm employment and non-farm employment are used interchangeably, but not in some others, while the difference is that working in others' farms is considered as off-farm employment but not non-farm employment. This study uses these terms interchangeably, Hence, rural off-farm employment, including wage employment in agriculture and elsewhere self-employment, full-time, part-time, formal, informal, seasonal, and episodic non-farm production are used in the same sense. And the distinction between rural and urban employment are based on the place of residence of workers. Thus, those who commute to a job in a nearby urban center are considered to be rural workers (Lanjouw and Lanjouw, 2001).

In poor rural areas, some households make a positive choice to take advantage of opportunities in the rural non-farm economy, taking into consideration the wage differential between the two sectors and the riskiness of each type of employment. Rising incomes and opportunities in off-farm, activities reduce the supply of labor on-farm Work. However, other households are pushed into the non-farm sector due to a lack of opportunities in on-farm activities, for example, as a result of drought or smallness of land holdings (Davis, 2003).

A farm household's choice of whether or not to work the off-farm sector depends on the reservation wage rate. If the reservation wage rate is less than the prevailing market wage rate net of commuting costs, the household will participate in off-farm activities (Singh et al, 1986).

However, a reservation wage rate that determines the households' participation in off-farm activities is an endogenous variable (Huffman, 1980). It depends on a number factors, such as farm characteristics, family characteristics and locations. Farm characteristics include the farm size (amount of land cultivated), livestock wealth. Family characteristics include age and educational level of family members, family size, and the number of dependents (Woldehanna et.al, 2001). Finally, variables that raise the reservation wage reduce the probability and level of participation in off-farm work, but the variables that raise the off-farm wage rate increase participation.

Very few empirical studies have been carried out empirically in Sub-Saharan Africa to identify factors that influence the decisions of rural farm households to participate in non-farm employment (Reardon, 1997). Previous studies on Africa focus on the share of non-farm income and employment to magnify the role of non-farm employment and income in rural poverty reduction.

Huffman and Lange (1989) applied bivariate probit model to identify factors affecting off farm labor supply decisions of husbands and wives jointly, but the result does not support the existence of joint decision making (husbands and wives) in off-farm labor supply decision. Thus, applying two univariaite probit estimation method is appropriate. The result from probit analysis shows that at a young age the probability that husbands participate in off farm work is higher, but tends to decline as they become older indicating the nonlinear of the life cycle of individuals which is consistent with the theory.

A husband and wife who have more schooling has a significantly greater probability of off-farm work than others. The implication is that the increase in off-farm wage because of additional schooling outweigh reservation wage (farming or home activities wage). The presence of children reduces the probability of off-farm participation for a husband as well as for the wife, while having older children (ages 11-18) do not affect either parent's probability of off-farm work. Child caring is more compatible with farming activities than off-farm work. But having older children do not affect the reservation wage of the parents' location (distance from the nearest city) which had a negative and significant effect on off farm work. Longer distance to the nearest city reduces the probability of participating in off-farm work, since the distance to the city reduces net wage through (transportation and time cost).

Mishra and Goodwin (1997) studied the effect Farm Income Variability on the Off-Farm Labor Supply of Kansas farmers and their spouses in USA. Simultaneous equations of Tobit estimation technique were applied in order to consider the joint decision of farmers and their spouses for off-farm labor supply decision. The result of their estimation like Huffman and Lange (1989) shows that spouses' off-farm labor supply does not influence significantly the operator's off farm labor supply or the other way round. Alternatively, off farm labor supply decision of a husband and wive is not jointly determined. Variability of earning and off-farm experience, and farm experience and land size affect off farm labor supply positively and negatively, respectively, while education and family size not have a significant effect on off farm labor supply of farmers and their spouses. According to this paper, a possible reason for the insignificance of education is that the academic return for farm and non-farm activities may be the same in the study area. In contrast to Huffman and Lange (1989), distance to town does not affect the off-farm labor supply decision of households..

Woldehanna *et.al*, (2000) studied off-farm work decisions of Dutch cash crop farmers. The result shows that family size, general education, age and age squared of the household head have a positive and significant effect on the off-farm participation decision. In contrast to Mishra’s and Goodwin’s (1997) finding, family size increases households' desire to participate in off-farm work. Households with a larger family size have a relatively higher marginal utility of income and a stronger desire to participate in off-farm work, which is consistent with the theory. However, they do not differentiate the age category in their estimation like Huffman and Lange (1989) did, since dependent and working household members have different effects on off-farm labor supply decision of husband and wive. Similar to Huffman’s and Lange‘s (1989) investigation, age and age squared of the household head show a significant quadratic age pattern on the participation decision. According to Woldehanna *et.al,* (2000), on the average, the desire of households to participate in off-farm work reaches its peak at the household head's age of 41.

Abdulai and Delgado (1999) studied the non-farm work participation decisions of married men and women in rural Northern Ghana. They applied bivariate probit model to analyze the joint as well as separate estimate for married couples to determine the probability of individual participation in non-farm work labor markets. The result suggests that a younger age is positively associated with the probability of labor supply to the non-farm sector, while in older ages, the probability of participating in non-farm work decreases. Having additional schooling had a significant and positive effect on the probability of supplying labor for non-farm activities for both husbands and wives, because additional schooling raises an individual's off-farm wage by more than it raises his or her reservation wage (wage for farm and home activities).

Similarly, family size increases the probability of participation in non-farm employment for males, suggesting that, at higher levels of family labor, extra effort is directed into non-farm work instead of into the farm. Moreover, the results indicate that well developed infrastructure and population density had positive significant effects on the probability of non-farm work participation. Most of the findings of Abdulai and Delgado (1999) are consistent with the theories despite the fact that, they failed to show the effect of land holding on off farm participation decision of a husband and a wife, which is the leading factor for off farm employment participation in developing countries. The result indicates that the presence of children had no significant effect on the participation decision of women in non-farm work, which contradicts with the theory as well as some other findings for example, Huffman and Lange (1989).

Yunez- naude and Taylor (2001) studied the determinants of non-farm activities and income of rural households in the Mexico, using a probit model regression analysis. In this case the dependent variable includes net income of six activities; production of staple crops, production of cash crops and livestock, non-farm self- employment, wage employment, migratory wage employment in Mexico and the United States. The result indicated that both primary (1-6) and secondary (7-9) education positively affect the likelihood of participation both in non-farm self- employment and wage employment. An additional member of a family with complete primary education or complete secondary education is associated with a positive likelihood of participating in the wage labor market. However, having an additional one year of schooling for the household head does not affect the likelihood of participation in any off- farm activities. Furthermore, an additional hectar of land had a negative effect on that probability of participation in wage employment. This implies the households participate in off- farm wage employment due to push factors, which is in line with the argument advanced by Reardon (1997) and Davis (2003), while increase in the number of livestock holding has a spur to participate in non-farm activities. In sum, the finding suggests that households participate in off-farm wage employment due to push factors, while the participation in non-farm activities is due to pull factors, like having more livestock.

Ruben and v. Den Berg (2001) studied the role of non-farm income for poverty alleviation in rural Honduras. Under the broad concept of poverty, they tried to determine the probability of individuals to participate in farm wage employment, nonfarm wage employment, and/or self employment for certain characteristics of farm households by applying logit regression model analysis. Similar to Yunez- naude's and Taylor's (2001) finding, the result proved that household's with small land and more hillsides is more likely to be engaged in farm wage employment, while a large farm size positively related to nonfarm wage employment participation.

In addition to the above, the result shows that the number of adults positively related with nonfarm wage and self employed, while credit negatively affects involvement in non-farm wage employment. In reality, engagement in nonfarm wage employment does not depend on credit, since income from nonfarm employment is a substitute for formal credit.

Like the finding of Abdulai and Delgado (1999) age and age squared significantly affect participation in wage employment positively and negatively, respectively. The possible reason suggested by the authors is that employment (access to rural labor market) increase with age, but for elderly this effect might be declining as a result of health related problems.

Unlike the finding of Yunez- naude and Taylor (2001), education level does not influence significantly the participation in self employment of household heads, while secondary education affect participation in wage farm employment and nonfarm wage employment. Reading and writing does not affect farm wage employment, but nonfarm wage employment. This finding is convincing, since it is compatible with reality. Because, most wage farm employment is done by unskilled and uneducated labor, in this situation experience is more important than education.

Corral and Reardon (2001) tried to explain the question of why individuals at primary level participate in off farm activities. They analyze farm wage employment, non-farm wage employment and nonfarm self employment separately through applying probit regression analysis. The result shows that age and age square influence the probability off-farm participation for individual positively and negatively respectively, which is consistent with the finding of Abdulai and Delgado (1999), Yunez- naude and

Taylor (2001) and Ruben and v. Den Berg (2001). In spite of that, the marginal effect of age square on off farm activities (the three employments) was almost zero. The authors also suggest that older persons tends toward nonfarm wage employment, but the result of their estimation does not support this argument, since the marginal effect of age square is the same for all employment, while the marginal effect of age is higher for nonfarm employment.

The effect of Education (as a categorical variable) on off-farm participation decision was very interesting. Starting from 'read and write' skill category, education does not significantly affect farm wage employment, like influencing self employment in the finding of Ruben and v. Den Berg (2001). Especially, pre-school level does not relate significantly to all of off farm activities, while reading and writing influence positively and significantly the probability of participation in non-farm wage employment and self employment. Primary, secondary and university levels are positively associated with the probability of nonfarm employment. The reason for this result suggested by the authors was the relative entry requirement for those activities.

In contrast to Ruben and v. Den Berg (2001), and Yunez- naude and Taylor (2001) findings, land size per adult negatively and significantly affects engagement in non-farm wage employment. Therefore, land scarcity was the driving force for participation in nonfarm wage employment. The combined evidences indicate that the inadequacy of the available land for household members leads for participation in farm wage and nonfarm wage employment.

De Janvry and Sadoulet (2001) studied the role of off-farm activities in rural households in Mexico by applying Multinomial Estimation Method.

They concluded that participation in off farm activities helps reduce poverty and contributes to greater equality in the distribution of income. The result of estimation shows that education, ethnic origin and regional availability of off-farm employment are found to affect participation in off-farm activities. Education helps the farm households in the studied area to participate in the more remunerative off-farm activities.

Generally, the above empirical evidence indicates that age, education, family size, land size and location of households determine off farm participation decision. The main limitations of those empirical literature are: Firstly, those studies failed to incorporate season as a variable to show its effect on off farm employment decision of households. Since, most households in rural area are causal worker, simultaneously cultivating their own farms and participating in off farm activities. Therefore, the supply of labor to off farm employment depends upon the time of agricultural cultivation period. During the peak agricultural work time, the available labor may be consumed in their own farms reducing off-farm labor supply. Secondly, those empirical evidences did not show the effect of individual and household characteristics on different participation levels. Households that participate in off-farm employment for some days or some months do not have a logical ground to say they have the same characteristics.

Beyene (2008) tried to find out the determinants of off-farm participation decision of farm households in Ethiopia. He applied bivariate probit model for male and female members of households separately to examine off-farm participation decision.

The result shows that education has no significant effect on the decision of male headed farm households to participate in off-farm activities, which is similar to the finding of Woldehanna and Oskam (2001), while the latter categorized education into traditional (religious) and modern. This result implies that the natures of off farm activities that are undertaken in Ethiopia do not need education, since the activities are primarily traditional and have no connection with modern or traditional education. In addition, the result shows that male headed households are more likely to participate in off- farm employment than female headed households and the financial position of male households, members has a positive effect on off-farm participation decision.

Size of land for cultivation has a negative effect on off -farm participation decision of both male and female members of a household. This result indicates that farm households are involved in off-farm work because of push factors, which is consistent with the theory of (Reardon, 1997 and Davis, 2003). Surprisingly, in contrast with the theory and most empirical research the estimated result revealed that, households, which are far away from the market show a positive effect on the participation decision of male members.

Woldehanna and Oskam (2001) investigated the determinants of income diversification, particularly, between wage employment and self-employment in northern Ethiopia (Tigray regional state). The authors split or divided off farm employment into wage employment and self-employment and then applied multinomial logit model to identify determinants of household choice of off farm activities, while Tobit model were used to find out the factors that affect off farm labor supply of households.

In their Tobit model analysis, age of the household head, the number of dependents and livestock wealth, and age square and family size are related negatively and positively to the probability of off-farm wage employment, respectively. The farm household’s probability and level of participation in off-farm wage employment increases with family size and decrease with the number of dependents. The implication is that, farm households are involved in off-farm wage employment due to push factors (insufficient farm and nonfarm income as well as surplus labor).

The negative impact of age on hours worked in off-farm wage employment, as suggested by the authors may be explained by the fact that due to high population pressure, young farm households cannot get enough land to support their livelihood compared to older farm households. Hence the younger households have to rely on off-farm employment to support their livelihood. However, the result is contrary to the findings of (Huffman and Lange, 1989; Abdulai and Delgado 1999 and Woldehanna et.al, 200) and the justification also contradicts with the nonlinear life cycle of individual characteristics.

On the other hand, farm size and education as dummy (traditional and modern) do not significantly influence the wage of off-farm labor supply decision of the household, which contrast with theories of (Reardon, 1997; Huffman and Lange, 1989) empirical finding of (Abdulai and Delgado, 1999 and Ruben and v. Den Berg, 2001).

Besides the above result, except livestock wealth, owned off-farm equipment and predicted wage rate of self employment, the remaining key variables that are included in the model do not affect off farm self employment significantly. Livestock wealth, non-labor income and cultivated land are thought to increase the reservation wage rate (wage for farm or home activities) and then reduce off-farm employment. An increase in the area of cultivated land reduces the probability and level of off-farm self-employment.

4. Econometric Model Specification and Estimation

Logit regression is a nonlinear regression model that forces the output (predicted values) to be between 0 and 1. Commonly, a logit model is used when the dependent variable is binary (also called dummy) which takes values 0 or 1, because it has advantages over the linear probability model, even if the linear probability model (LPM) which is expressed as a linear function of the explanatory variables is computationally simple. Despite its computational simplicity, it has a serious defect because the estimated probability values can lie outside the normal 0-1 range. Hence, Logit model is advantageous over LPM because the probabilities are bound between 0 and 1 (Gujarati, 2004). Moreover, Logit best fits to the non-linear relationship between the probabilities and the explanatory variables, since it is nonsense to say that the probability of response variable is linearly related to the explanatory variables.

In most literature binary Logit model was used by many researchers to identify the determinants of off-farm participation. However, this type of analysis is crude, and it may lead to biased and imperfect conclusion. To avoid this limitation this study has employed ordered logistic regression model. When a dependent variable has more than two categories and the values of each category have a meaningful sequential order where a value is indeed ‘higher’ than the previous one, it is recommended to apply ordered logistic regression (Wooldrige). The model is treating the response variable, in this case off-farm participation, as ordinal scale, but the ordinal scale is a crude measurement of underlining interval or ratio scale. In this study off-farm labor supply of households is continuous; it can be measured in the interval or ratio scale. As a result, this model allows to find out the determinants of off farm participation at different levels of labor supply. Nevertheless, this ordinal response variable can be estimated by linear probability model, which will come up with the above mentioned nonsense result.

As already noted, the purpose of this analysis is to identify which and how much the hypothesized explanatory variables are related to the dependent variable. The dependent variable, in this study is off farm employment participation in ordinal form.

Off farm Participation by household head is ordered based on the total amount of labor supply to off farm activities. If a household participates in off farm employment less than 15 days per year, which is almost one day per two weeks, and considered as a non participant in this study, since the degree of participation has a negligible effect on the overall livelihood strategy of the household. On the other hand, a household which is supplying labor to off farm activities of up to 25 percent of the total labor supply is considered as a participant because with so this much labor supply, the household can buy 50 kgs of fertilizer in the market, while beyond 25 the percent participant is expected to be off farm activities as its main livelihood strategies. Basically, the objectives of the study is not to know the level of participation, while participation rate is ordered in order to avoid rushing of data simply by making binary choice. Based on this assumption, if the household head is employed in off farm activities less than 5 percent, between 5- 25 percent and more than 25 percent of total working days, take off farm participation value of 0, 1, and 2, respectively.

In the ordered logistic regression there is an observed ordinal variable, Y, in turn, Y is a function of another variable, Y*, that is not measured, but it is continuous, whose values determine what the observed ordinal variable Y equals. This continuous latent variable Y* has various threshold points. This ordered logistic regression has two cut points (thresholds). Following the ordered logistic model specified as:

$$Yi = 0 if Yi^* \leq \sim 1$$
$$Yi = 1 if \sim 1 \leq Yi^* \leq \sim 2 \quad \ldots\ldots(1)$$
$$Yi = 2 if Yi^* \geq \sim 2$$

Definition of Variables and Hypothesis Setting

Age of household head (AGE and AGESQ): as age has a nonlinear effect on decision of households to participate in off farming activities. Therefore, the age of the household head is expected to have a positive effect on degree of participation while the age square is expected to have a negative effect on off farm participation of farm households. Therefore, the expected sign of age and age square of the households is positive and negative, respectively.

Education status of the household head (DEDUC): A categorical variable named as illiterate, primary, and secondary and above. The number of years of schooling achieved by the household head is expected to have a positive effect on the level of participation since education raises the reservation wage of farm households and Higher level of educational achievement may lead to better assessment of the importance and complexities of good off farm and farming decision. Then the expected sign for education is positive.

Location (DLOC): Theoretically, location of the rural households relative nearby urban center has an important influence on the off farm participation decision of farm households. The location of the households takes values of 0, 1, and 2 for households located less than or at 10 Km, between 11-20 kilometers and above 20 kilometers, respectively. A household, which is far away from the nearby town is expected to be less likely to participate in off-farm activities compared to those close to nearby town households. Therefore, the expected sign of dummies relative to the reference category will be negative.

Land size (Lansize): Land size of farm households are expected to have both negative and positive effects on off-farm participation decision of farm households via push and pull factors. Hence, the sign of land size is difficult to determine *prior.*

Marital status of the household head (DMarstatus**):** This variable is also formulated as a three dummy variables, which are single, widowed and divorced with reference category of married household heads. The expected sign of the three dummies is also difficult to determine prior since couples may consume substantial time for leisure than work or encourage each other for extensive work.

The number of dependents in the households (Depndt): the number of dependent family members may promote the household to participate in off farm activities. Therefore, the expected sign of this variable is negative
Access to credit (CRDT): Farm households participate in off-farm activities to relax the credit constraint faced in rural areas. Therefore, access to credit determines off farm participation households. Access to credit is captured by dummy variable 1 to those who have access and 0 to those who have not, the expected sign of credit dummy will be negative

Seasons: This variable is categorized into two; weeding and planting, and post harvesting. The farm households are expected to participate in off farm activities during slack periods, i.e. post harvesting and less likely to participate in peak time agricultural production. The expected sign of weeding and planting, and post harvesting is positive and negative, respectively.

5. Estimation Results and Discussion

5.1 Determinants Of Off Farm Participation: Evidence from Ordered Logistic Regression

In this section results from ordered logistic regression models are presented. The dependent variable is ordered off farm participation. The overall model is significant at the level of 0.1 percent. This means at least one of the parameter estimate has significantly influenced the ordered off-farm participation of farm households and the probability to get all insignificance coefficients is 0.1 percent.

The problem of heteroscedacity was corrected by estimating the robust standard error of the coefficients and the existence of multicollinearity between explanatory variables were checked through Collin test. However, through pairwise correlation test, age and age square of the household head, and seasonal based off farm labor supply are significantly correlated. Consequently, the variance inflated factor (VIF) for these variable beyond the rule of thumb. The multicollinearity between age and age square is corrected through deduction of mean age of the farm household head. Season based off farm labor supply of farm households cannot be corrected through transformation of the variable; hence the only option is dropping the variable which is high VIF value relative to the other.

Based on this, off farm labor supply farm households during planting and weeding seasons (from May to August) was excluded from the model because it has strong multicollinearity with off labor supply of farm households during slack agricultural season (from March to April). One can get approximately similar information from the two parameter estimates, since the pairwise correlation is 0.95 and significant at 0.1 percent. Therefore, dropping the variable of off-farm labor supply of households during planting and weeding create any clarity about the effect of that season, hence excluding this redundant information is preferred. Generally, the problem of multi-collinearity has an effect on the significance level via standard error of the parameter not the coefficient of the variable. The remedial measure for the correcting multi collinearity problem is dropping the variable that is highly responsible for the problem (high VIF). By doing so there is no difference in significance level as well as coefficient of the parameters. Moreover, theoretically these variables have do not base (ground) for their correlation; hence, the multi-collinearity may be a matter of mechanical issue. The correlation between dummy variables are tested by the coefficient of contingency, and the result shows that all the correlation coefficients are below 0.75, thus none of the dummy variables are correlated significantly with each other. Finally, after excluding planting and weeding of labor supply, the Collin test result of condition index is 13.7, indicating that the model coefficients and significance are stable for any variable and observation changes because it is below the minimum standard of 15.

Furthermore, the proportional odd assumption or violation of parallel regression assumptions was tested by applying the BRANT test. In this ordered logistic regression there is only one coefficient, while actually the equations are two because three order logistic regressions have two equations. The test provides evidence that whether the two equations have similar coefficients or entertain each equation individually. The results of the test show that all coefficients except the coefficient of the number of dependent household members, the remaining variables included in the model are not statistically significant at 5 the percent level (no violation of parallel regression). Therefore, the coefficients of the regression are the same in the two equations. At the beginning, the effect on number of dependent household members on off farm participation is not significant. So, having similar or different coefficient is less important.

Finally, how the ordered logistic model fits for off farm participation of households was tested through FITSTAT test. The McKelvey & Zavoina's R2, which is similar in meaning to OLS R2, is 0.883 and the chi2 is less than 0. 1 percent, hence, the ordered logistic regression model is well fitted to the off participation of farm households.

Estimation results for the determinants of off farm participation are presented in Table 7. The results reveal that ordered participation in off-farm activities is mainly influenced by marital status (single dummy and divorced dummy), the number of adults in the household, land size and post harvesting seasons. However, age and age square of the household heads, the number of dependent family members, primary and secondary education dummies, credit and location dummies of farm households not explain the variation in ordered off farm participation decision of farm households.
Age and age square of the head is not statistically significant at the commonly accepted significance level, while age has positive but declining effects on ordered participation since the linear term has positive and the quadratic term has negative coefficients, which implies that farmers participate in off-farm activities at a decreasing rate as they age, and the turning point of age is 39. Educational dummies of the household heads do not significantly affect categorical off farm participation decision of farm households. Education has a strong effect on off farm participation decision of farm household both in developed and developing nations. In the case of Ethiopia, education does not explain the variation in ordered off- farm participation decision of farm households because most of off farm activities in Ethiopia are traditional and did not require education. Beyene (2008), Woldehanna and Oskam (2001) find similar results. Alternatively, the academic return for farm and nonfarm activities may be the same in the study area.

Marital status of farm household dummies influence ordered off farm participation decision at 1 percent significance level. Being single or divorced for a farm household head has a positive effect on ordered off farm participation as compared to married farm household's head. The odds of being a participant at higher or medium level versus no participation are about 23 and 13 times higher for single and divorced household head than a married one. Alternatively, married households are less likely to participate in off-farm employment as compared to single and divorced households. At the mean level of all predictor variables the change in probability of non participation of farm household negatively and significantly associated with single and divorced farm operators, compared to married farm operators. However, the effects of single and divorced farm operator dummies are not statistically different from married household heads on probability of high and medium participation off farm employment

The other demographic variable that influences ordered participation of farmers in off-farm activities is the number of working age group of family members. The number of family members at working age (15-64 years) group positively affect ordered off farm participation at 5 percent significance level. Specifically, households with more working age group family members are more likely to be a higher participant instead of being a medium and non participant, and less likely to be non-participating in off-farm employment (activities) than medium and higher participants. At the mean level of adult family members, the change in probability of high and medium participation in off farm employment associated with an increase of adult members is positive, holding other variable in the model constant. An increase of one adult family member raises the probability of being at high and medium participation versus non participation of the households by about 53 percent. This result implies that households participate in off employment by a push factors (availability of surplus labor in the households) and support the finding of Woldehanna and Oskam (2001) in the Tigray National Regional State.

Table 7: Results from ordered logistic regression

Dependent variable is ordered of farm participation

Variable name	Coefficient	Odds Ratio	Marginal prediction participation n=0	Marginal prediction participation n=1	Marginal prediction participation n =2
Age of HH head	.0072873 (0.21)	1.007314	-0.00182163	0.0012812	0.00054039
Single household head (D)	3.120674*** (3.17)	22.66166	-0.5 1894559	0.0188639 5	0.53780947
Divorced household head (D)	2.540574*** (3.26)	12.68696	-0.44718157	0.0174773 3	0.42970423
Widowed household head (D)	-0.6745874 (-0.02)	0.5093666	0.1623674	-0.1239754	-0.03839191
Primary education (D)	0.2186693 (0.32)	1.24442	-0.05460456	0.0384182	0.01618634
Secondary and above education (D	0.3383769 (0.43)	1.402669	-0.08426765	0.0569616	0.027306
Adult household member	0.4249191** (2.28)	1.529467	-0.10621767	0.0747077	0.03150997
Dependent household member	0.1591704 (1.19)	1.172538	-0.03978806	0.0279847	0.0118033 1
Land size	-0.615427 1*** (-2.74)	0.5404101	0.15383923	-0.1082021	-0.04563712
Off farm labor supply of household between Jan -April	0.0861 191*** (2.37)	1.090014	-0.02154529	0.0151537	0.0063915 1
Distance 11- 20 Km(D)	-0.5684354 (-0.90)	0.5664109	0.13985318	-0.1031892	-0.0366639
More than 20Km(D)	1.359972 (1.30)	3.896084	- 0.31155193	0.1582278	0.15332412
Credit (D)	-0.1052947 (-0.24)	0.9000593	0.02631351	-0.0185267	-0.00778677
Age square	-0.0046001 (-0.60)	0.9954105	0.00114988	-0.0008087	-0.00034112
Cut 1	3.504077*** (1.076048)	3.504077** (1.076048)			
Cut2	5.916118*** (1.22899)	5.916118** (1.22899)			
N	221	221			

Pseudo R2 0.64

Wald chi2 82.20***

(D) Marginal for discrete change of categorical variable from 0 to 1 * p<0. 10, ** p<0.05, *** p<0.01, values in parentheses are z-values.

Land size has a negative influence on the probabilities of ordered participation in off farm employment. Having more land (owned) makes households less likely to be a higher participant than medium or non participant, and more likely to be a non- participant instead of being medium and high participant in off-farm activities. If the size of the land is increased by a marginal (one hectar), it will reduce the probability of farm households being a high participant instead of being a medium or non participated in off-farm employment by about 54 percent. The change in probability of high and medium off farm participation is negatively and significantly associated with an increase in land size, while the effect on probability of non participation is positive and significant. This result also reveals that farm households join off farm activities by push factors (shortage of land). This finding supports the views of Davies (2003) which state that push factors determine off farm participation of farm households. Consequently, Lack of opportunity on farms leads household to join off farm employment. Therefore, one can safely say that these variables characterize most of the poor farm households in rural Ethiopia, which implies that poor farm households participate more in off-farm activities. Furthermore, this result supports the finding of (Mishra and Goodwin, 1997, and Beyene, 2008).

The other highly influential determinant of off farm participation of farm households is season variation in farming activities. The result shows that post harvesting (January-April) season affect the probability of ordered off farm participation decision of farm households positively and significantly. This result backs the finding of Jemal (1995) in Pakistan.

During post harvesting season, a farm household is more likely to be a higher participant in off farm employment rather than medium or non participant at one percent significance level. Quantitatively, the odds of being a high participant versus medium or nonparticipant are increased by about 9 percent. In other words, the rise in probability of farm households being a higher participant in off- farm activities instead of being a medium or non participant during post harvesting for a marginal increments is about 9 percent. At the mean value of off farm labor supply between (January to April) the effect of post harvesting season on probability of high and medium participation of farm households is positive and significant. Intuitively, it is logical because during slack periods of agricultural production (post harvesting) family labor free from on farm activities, and consequently it allocated in off farm activities. It seems that farm and nonfarm activities do not compete for limited labor during post harvesting season.

Similarly, a farm household is more likely to be a higher than a medium participant in off farm activities during planting and weeding season. However, this variable was dropped because of collinearity with post harvesting season. Although these two seasons give the same information about off farm labor supply decision of farm households while the implication on other socioeconomic activities of rural households is entirely different. For instance, the greater off farm labor supply during planting and weeding is counter intuitive because in peak agricultural production time, family labor is exhausted on the farm, as a result of which labour available to allocate for off farm activity becomes low. However, during this period, it is expected that farm households are more likely to be net buyer of food and need cash to purchase farm inputs (fertilizer, seed and labor). In order to meet these needs the farm household is engaged in off farm activities since the household has spent its off-farm income on consumption. This evidence is consistent with the previous analysis, i.e. (off farm labor supply adversely affects agricultural production). Thus engaging in off farm employment during planting and weeding season affects agricultural production negatively.

One type of interpretation of results that works exclusively for ordered logit is the interpretation of dependent variable standardized and fully standardized coefficients as the change (measured in standard deviations) in latent dependent variable per unit of predictors or per standard deviation of predictors. The Table below shows that a one hectar increase in land size decreases farm participation by 0.13 standard deviation, and one standard deviation increases in land size (1.69 hectars), decreases off farm participation by 0.21 standard deviation. On the other hand, having one additional adult family member increases off-farm participation by 0.09 standard deviation, and one standard deviation (1.2) increases in adult family member of the farm household increases off -farm participation by 0.10 standard deviation.

On the other hand, harvesting season does not significantly affect the probability of off farm participation of farm households. The possible reason is that during this time the demand for farm labor is covered by labor sharing agreement and non local farm labor, as a result of which labor market imperfection is created.

Location (distance) of a farm household from a city does not explain the variation in the probability of participating in off farm employment. This is because most off farm activities undertaken in the study area have no correlation to the location of a town. The other possible reason is that off farm participation does not depend on location of farm households because society tries to be self sufficient by providing goods and services, and supplying inputs, which increase the intensity and participation in off farm employment. Beyene (2008) finds that the more far away a household from a town is the higher the probability of its participation in off-farm activities.

Table 8: Result from ordered off farm participation in deviation form

OFF_PARN	b	z	P>z	bStdX	bStdY	bStdXY	SDofX
Agem	0.00729	0.210	0.834	0.0660	0.0015	0.0135	9.0537
AgemSQ	0.00460	-1.297	0.195	-0.5856	-0.0009	-0.1196	127.3015
DPEDUC	0.21867	0.325	0.745	0.1095	0.0447	0.0224	0.5009
DSEDUC	0.33838	0.432	0.665	0.1377	0.0691	0.0281	0.4069
SMarstatus	3.12067	3.167	0.002	0.8973	0.6376	0.1833	0.2875
DMarstatus	2.54057	3.261	0.001	0.4756	0.5191	0.0972	0.1872
WMarstatus	0.67459	-0.025	0.980	-0.1005	-0.1378	-0.0205	0.1490
BDist_Welk	0.56844	-0.904	0.366	-0.2255	-0.1161	-0.0461	0.3968
GDist_Welk	1.35997	1.304	0.192	0.4669	0.2779	0.0954	0.3433
AgeB15_64	0.42492	2.275	0.023	0.5059	0.0868	0.1034	1.1906
DEPNTH	0.15917	1.186	0.235	0.2707	0.0325	0.0553	1.7005
Lansize	0.61543	-2.737	0.006	-1.0394	-0.1257	-0.2124	1.6889
OFFJa_Ap	0.08619	4.555	0.000	3.8482	0.0176	0.7862	44.6469
OFFSe_De	0.00370	0.262	0.793	0.1645	0.0008	0.0336	44.4624
CREDITT	0.10529	-0.237	0.813	-0.0526	-0.0215	-0.0108	0.5000
TTLS	0.03707	0.575	0.565	0.2004	0.0076	0.0409	5.4056

Furthermore, the number of dependent family members do not affect off farm participation of the household heads. This may happen when the marginal utilities of consumption, which increase off farm participation cancel out by the time allocated for the care of the dependent family members (child). Similarly, Abdulai and Delgado (1999) finds that the number children do not affect off farm participation, while Huffman and Lange(1989) say the existence of a child influences off-farm participation negatively. At the same time older children (11-18) do not affect off farm participation decision of households. Therefore, off farm participation decision is not affected by the total number of dependents in a household.

In general, for all average value of predictors, the probability of farm households in off farm employment is 49 percent, medium participation is about 43 percent and high participation is 8 percent. On the other hand, given that all other variable remain in their mean, farm households who have 2 hectars of land and 4 adult family members, the predicted probability being non, medium and high participant in off-farm employment is 0.40, 0.48 and 0.12 percent, respectively. In the prediction of probability of participation estimation, land size is increased from the average only by 0.3 hectar and adult family member is increased by one from the mean, while non participation in off farm employment declines by 9 percent, medium and high participation increases by 5 and 4 percent, respectively. Intuitively, one can say 0.3 hectar of land and one additional adult household member have comparable magnitude effect in off farm participation but in the opposite direction.

6. Conclusion and Policy Implication

6.1 Conclusion

The survey data collected from 221 farm households reveal that farmers are overwhelmingly dependent on agricultural crop income that make up an average of 83.8 percent of total income, while the average share of off -farm income is 16.2 percent, which is an indication that off- farm activities are not the finest choice of farm households.

The finding of the study proves that households show a tendency to participate in off farm employment is driven by push factors. The result from ordered logit model showed that participation in off farm activities is mainly explained by seasonal variation of farming activities and wealth indicator. Some level of off farm participation among households is not significantly determined by demographic and liquidity indicators, whereas having a adult household family member is found to have significant impact on off farm participation.

Therefore, households seem to opt to engage in some form of off farm activities due to demographic factors such as availability of surplus labor not needed in agriculture and insufficient land size. Hence, initially push factors determine off farm participation decision of farm households, while in the mean time participation decision may not be explained by push factors. This needs further study considering the time (dynamics) of off farm participation. The second finding of the study is that off farm employment has a certain effect on welfare or poverty reduction rather than intensification since the lion's share off farm income which is close to 63.4 percent is spread out to smooth consumption, while farm inputs account for 14.6 percent and the marginal saving rate is 12.2 percent of off farm income. This may indicate that off farm employment is important to welfare improving of rural farm households. Consequently, it has a positive effect on poverty alleviation of rural poor households via labor market channel.

6.2 Recommendations

Intervention in the labor market is the critical avenue for rural poverty reduction. Off farm employment is the livelihood strategy for rural poor farm households. Especially, households who do not have or have only insufficient farm plots and a high proportion of adult family members immediately benefit from the labor market correction. At the same time, getting labor market perfection is important for both off farm employment participants and farmers. Therefore, the government should intervene in the labor market via enforcing contracts, crafting agreement, setting minimum wage for a daily farm laborer, and providing labor market information in organized forms and removing other barriers. Therefore, off farm employment is the means to help escape rural people from poverty since most the income generated from off farm employment is spent on household consumption.

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THE IMPACTS OF EDUCATIONAL EXPENDITURE ON GROWTH, LABOR MARKET AND POVERTY: A Recursive Dynamic Computable General Equilibrium Analysis

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Abstract

This study deals with the impact of expanding educational expenditure on macroeconomic variables (growth, consumption, investment, export and import), labor market and poverty. The financing mechanisms to meet the desired increase in educational expenditure (20% p.a growth in GTP) the government savings, foreign savings and a mix of the two. The macroeconomic variables and labor market changes due to expanding educational expenditure are solved using the recursive dynamic computable general equilibrium model which further uses the social accounting matrix (SAM) of 2009/10 as a data source. The poverty changes are analyzed through Distributive Analysis Software which serves the purpose of channeling education benefits in- to poverty reduction.

The major findings signaled out that expanding public educational expenditure secures not only higher economic growth but also lower poverty rates through increasing total factor productivity and consumption expenditures due to advancements in factor incomes. Moreover, expanding educational expenditure will bring about a promising result in increasing the number of skilled and semi-skilled labor. But the income inequality change due to the policy shock is mixed. The urban inequality improves a little whereas the rural one is worsened. This is because education increases the consumption expenditure of the rural non-poor more than the rural poor. Finally, observing the response of the economy for the same percentage decrement and increment from the planned expenditure in GTP, the economy was found to be more responsive for education budget cuts than increments.

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1. Introduction

The state of poverty in Ethiopia is among the worst in the world measured by most socioeconomic and human development indicators. As evidence of this, the country is rated 157th out of 169 countries in the UNDP human development index in the year 2010. Hence, it requires the country to continue the recent growth performance with a special emphasis on the poor for a number of years to improve its state of poverty (HDR, 2010). In other words, the Ethiopian government is facing a big challenge, to promote equity while simultaneously encouraging economic growth.

Education has the potential to contribute to both of these objectives as a source of human capital accumulation to spur growth and to allow the poor to escape poverty through higher income. Conversely, reductions in public spending on education seem likely to have negative effects by increasing the cost of education, reducing educational investment and increasing the skills premium, which generally favors the non-poor, in the labor market. Yet, little is known about the actual impacts, notably taking into account the powerful general equilibrium effects of such a widespread policy on educational choices, the skilled wage gap and, ultimately income distribution.

The educational sector in Ethiopia has been given a powerful impetus after the overthrow of the military government in 1991. Since then education has been a development priority on the government agenda. The Government of Ethiopia developed Education Training Policy (ETP) and Education Sector Strategy in 1994 (Transitional Government of Ethiopia, 1994; Ministry of Education, 1996). The Government issued the Education Sector Development Programme (ESDP) in 1997 together with the Education Training Policy.

To meet the above and other related educational programs, the Ethiopian government spends a significant share of the GDP on education. In the time of the Derg the educational expenditure as a percentage of GDP was on average 2.46% whereas in the EPRDF government the figure rose to 4.44%. (World Bank, 2003b & MOE 2010.)

Moreover, by international standards, relative to the level of per-capita income, Ethiopia spends significantly more than India, whose per-capita income is almost four times as much, and only a little less than South Africa whose per-capita income is more than 14 times that of Ethiopia (UNSECO, 2006).

For the whole period of the growth and transformation plan (GTP) which lasts from 2010/11-2014/15, the government planned to spend nearly Birr 140.627 billion (in 2010/11 prices) to finance the educational sector. This sum of money is nearly the country's total annual budget for the year 2012/13. This budget is intended to meet not only millennium development goals but also the country's vision of being a middle income economy through producing skilled, creative and efficient labor (MOFED, 2010).

All the above situations ignite a question about the effectiveness and efficiency of government spending on education which is mainly measured by its impact on growth, skilled labor supply, income distribution and poverty.

It is hotly debated about the extent of the contribution of education to growth, and to reduce income inequality within a country. Schultz (1961), Blaug et al (1969), Psacharpoulos (1993) tried to show that investment in education yields a higher return than investment in physical capital. On the other hand, V.P.Ojha et al (2005), Predhan and Singh (2004) did not come up with a significant positive link between education and expected education outcomes for India and South African countries. They offered various explanations for the absence of a strong positive association between educational expenditure and educational outcome. To mention some, corruption, non-motivated and discouraged teachers, poorly equipped schools, unwillingness of parents to send children to school due to economic and non-economic constraints are the main challenges hindering benefit from investing in education.

Hence, the first question that should be answered is the extent public educational expenditure in Ethiopia contributes to economic growth and related macroeconomic variables. Moreover, Johan et al (2005) and Lumengo (2007) emphasize that the return from education depends not only on its amount but also on the way that the intended expenditure is financed.

Secondly, the income inequality issue is equally important as that of the analysis of growth since their combined impact leads to have a concrete clue about poverty. Kuznets's famous hypothesis asserts an inverted U-shaped relationship between growth and inequality. However, Ravallion and Chin (1997) did not find a defined and consistent relationship between the two. It is not the great concern of this paper to analyze the relations between growth and inequality, but the extent educational expenditure in Ethiopia affects income inequality. Even though educational expenditure reduces income inequality (Lacina et al, 2011)), Pradhan (2000) using computable general equilibrium model finds an interesting paradox for India that there is not much change in income inequality with increasing educational level and expenditure.

Finally, the educational policy of Ethiopia was assessed by the World Bank (2005) to examine the capacity of the policy to address the issue of equity, relevance, effectiveness, and efficiency. Johan et al (2005), Tekeste (2006) tried to evaluate education and training in Ethiopia especially with regard to meeting education for all (EFA) goals. Alemayehu (2004) in his paper about the political economy of Ethiopia discusses the role of education on the historic growth of Ethiopia. But economy wide impact of educational expenditure is not analyzed till now using a dynamic computable general equilibrium model. Investment in education affects the economy mainly in the long run. If a need arises to identify clearly this impact of education on the economy, the best model to be adopted is dynamic CGE model since it includes not only the time element in the analysis but also the government's spending impact on factor productivity which can be collected easily. Moreover CGE models are currently used to analyze government expenditure-poverty issues for their ability to illustrate the feedback effect between different markets and produce disaggregated results at sectoral or microeconomic level within a consistent macroeconomic framework (Wang et al, 2010).

2. Objectives of the study

The general objective of the study is to analyze the impact of public educational expenditure on major macroeconomic variables, labor market and poverty, using a recursive dynamic computable general equilibrium model.

The specific objectives are:

1. investigating the impact of expanding educational expenditure on;
2. major macroeconomic variables such as real growth rate of GDP, absorption, investment, export, import…etc;
3. studying the supply of unskilled, semi-skilled and skilled labor and corresponding changes in the wage rate;
4. analyzing impact of education on poverty;
5. identifying the optimal way of financing the targeted increment in public educational expenditure; and
6. assessing the responsiveness of the economy to a change (increment/decrement) in educational expenditure from its projected growth on macro variables and poverty.

3. Review of related literature

According to the endogenous growth model, the pace of technological change should have an economic explanation and factors such as human capital, educational attainment and educational expenditure, to mention but a few, should affect technological change and therefore economic growth (Gylfason, 1999).

In the endogenous growth theory, the path of economic growth is dictated by the level of technological change, which is determined mostly by the level of research development and learning by doing. The concept of technological change is attributed to the fact that technological change is not exogenous (as stipulated by the classical thinkers) but endogenous as it depends on the above factors.

The model of endogenous growth also provides the very important insight that knowledge and skill are the key inputs for the creation of new ideas. This provides the most plausible justification for perceiving education as a central determinant of growth rates over a long time interval.

In view of the above realities, one can infer that the relationship between educational attainment or educational spending and economic growth should amount to the relationship between educational attainment or educational spending and technological change. If expenditure on education could affect technological change, it could be inferred that educational spending should also affect economic growth. This is the path followed in this paper to measure the relationship between educational spending and economic growth.

To analyze the relationship between economic growth and education, different studies used different proxies for education. Some used educational attainment represented by years of schooling, and others used government educational expenditure to explain the relationship between education and economic growth. This study uses government educational expenditure to explain economic growth due to the following reasons:

- If the marginal product of physical investment (which determines the real return on investment) is explained by how a change in investment expenditure would lead to a change in output, marginal product on educational expenditure (which defines how the change in educational expenditure would affect the change in output) should be an appropriate indicator of the real return on education.

- If assessment of the relationship between government educational expenditure and economic growth shows that the former does not government educational expenditure does not cause a change in output, it may lead to the conclusion that government education expenditure does not translate into human capital formation or innovation. According to the endogenous growth model human capital development, innovation and skill accumulation are important ingredients for technological change, and therefore economic growth.

Loening (2002) investigates the impact of human capital on economic growth in Guatemala through the application of an error correction methodology. He examined two different channels by which human capital is expected to influence growth. The result from his study revealed that a better-educated labor force appears to have a positive and significant impact on economic growth both via factor accumulation as well as on the evolution of total factor productivity.

Specific to public educational expenditure, Chu and others (1995), and Tanzi and Chu (1998) argue that public expenditure allocations for education can improve economic growth while promoting equity. They suggest that both the size and the efficiency of public educational expenditure are important in improving socioeconomic performance in countries like South Africa.

Lacina et al (2011) on Burkina Faso found that increasing public educational expenditure was a means for spurring capital accumulation and wage which have in turn a positive impact on growth promotion and income inequality reduction. Conversely, reductions in public spending on education seem likely to have strong negative effects by increasing the cost of education, reducing educational investment and increasing the skills premium, which generally favors the non-poor, in the labor market.

As far as Ethiopia is concerned, there is no detailed output done that shows specifically the general equilibrium impact of educational expenditure on the economy. But research undertook by Alemayehu (2004) on the basis of Collin's and Bosworth's growth accounting based decomposition of source of growth for Ethiopia indicates on average the role of education for the overall growth to range from nearly 2% to 9.46%% for the period 1960-2000.

All the empirical literature that is reviewed above are inputs to show the skeleton about the impact of education on growth and poverty. What is also important is that the above analysis employ partial equilibrium to show the relationships. Partial equilibrium analysis of public policy is handicapped by a number of problems as observed from the following literature.

Two of the most frequently used partial equilibrium analyses of public policies impacts are *benefit incidence analysis* and *behavioral approaches*. Benefit incidence analysis assumes that benefits to the consumer of a public service are equivalent to the cost per user of furnishing this service. These benefits are assigned to users ordered according to some welfare measure, which makes it possible to evaluate whether they are progressive or regressive. Although this technique is widely used, criticisms are also numerous. There are strong reasons to believe that public spending is not distributed evenly and does not benefit each user to the same degree. Moreover, this approach does not take account of individual reactions to policy changes.

Behavioral approaches, developed by Gertler et al. (1987) and others, analyze changes in policies over time or in space to econometrically estimate the effects of public spending on monetary and non-monetary welfare measures while controlling for other factors is likely to influence these measures. They find that beneficiaries and non-beneficiaries significantly adapt many aspects of their behavior to changes in public spending. But these approaches are limited by probable estimation biases resulting from endogeneity and omitted variables.

Educational policies have important general equilibrium impacts, in particular through their influence on relative wages of skilled and unskilled workers, which have clear poverty implications. For this reason, partial equilibrium analysis does not adequately reflect the magnitude and even the direction of actual impacts. In order to overcome these problems of partial equilibrium analysis, what is suggested is the usage of computable general equilibrium models.

In CGE models, general equilibrium effects can be accounted for, interactions of different measures can be investigated, complex micro-macro relationships can be performed better, and constraints of linearity can be reduced to the minimum (Iqbal and Sidiqqui, 2001). Besides, these models have the ability of examining a variety of incidence assumptions and socioeconomic divisions including various welfare measures and behavioral responses. These models are also consistent with generally accepted microeconomic theory, have significant structural detail and their general equilibrium nature-changes in one area of economic activity affecting the rest of the economy-elevates their influence for economic analysis (Bibi *et al.,* 2010).

Cloutier *et al.* (2004) constructed a static computable general equilibrium model to study the impacts of public education spending on poverty, welfare and inequality in Vietnam. Their approach is particularly interesting because it introduces a household endowment of qualified and unqualified workers that is flexible for each household category. The household's decision to invest in education results from a trade-off between future benefits (higher income) and the direct and indirect costs of education. The government can thus influence the household decision by reducing the household cost of education, with a resulting increase in educational spending.

Hang-Sang and Thorbecke (2001) in their study about the impact of public educational expenditure in the economy of Tanzania and Zambia found that significant poverty alleviation can be achieved most efficiently through better targeting of educational expenditure to the poor. But what they underline is the importance of enhancing the demand for labor through appropriate pattern of economic growth since increasing public educational expenditure has the impact of reducing the opportunity cost of education and in turn increasing labor supply. But their analysis is silent as far as the means of financing the incremental education expenditures are concerned.

Zhai and Hertel (2006) developed an economy wide model for China where educational expenditure affects the production of human capital, its distribution among different household groups and the skill composition of each household. Each household is endowed with different categories of workers distinguished by their total years of schooling. Education results in a greater supply of skilled labor and lesser supply of unskilled labor and in an improved mobility of labor in rural areas. Simultaneously for each skill level, more education yields, in a linearly increasing manner, an improvement in labor productivity.

Savard and Adjovi (1998) introduce externalities from public spending on education in a static model while Lofgren and Robinson (2004) specify the impact of government spending on total factor productivity growth in a recursive model. The policy impact on households is thus indirectly channeled via the production level in the economy. It is this approach that is more appropriate to meet the objectives of this paper.

4. Methodology

A. The model

In this paper the economy wide impact of educational expenditure is analyzed using a recursive dynamic CGE model which is an extension of the standard CGE model of the International Food Policy Research Institute. This kind of dynamic model is based on the assumption that the behavior of economic agents (private and public) is characterized by adaptive expectations: economic agents make their decision on the basis of past experiences and current conditions with no role for forward-looking expectations about the future. This is an alternative that captures the developing countries' reality better than inter-temporal dynamic models that can be explained by economic agents which have forward looking (rational expectation) and make inter-temporal optimal decisions, in which everybody knows everything about the future, and they use that information to make decisions.

According to Lofgren and Robinson (2004) a recursive dynamic model can be divided into a “within-period” module (in essence a static CGE model) and a “between-period” module which links the within-period modules by updating selected parameters (typically including population and factor productivity) on the basis of exogenous trends and past endogenous variables.

Information from past solutions can also be used in the between-period modules to generate expectations about the future, which might be used to affect agent behavior in later within-period modules. Dynamic-recursive models can be, and often are, solved recursively, the within-period modules are solved separately in sequence and the between-period modules are solved to provide parameters needed for the within-period model in the succeeding period.

Structures of the within- period model

The structure of the within-period models consists of four majors blocks; price block, production and trade block, institutional block and system constraint block.

a. Price block

The price block consists of equations in which endogenous model prices are linked to other prices (endogenous or exogenous) and to non-price model variables. The price system of the CGE model is rich primarily because of the assumed quality differences among commodities of different origins and destinations (exports, imports, and domestic outputs used domestically).

b. Production and Trade block

The production and trade block covers four categories. Domestic production and input use; the allocation of domestic output to home consumption, the domestic market, and exports; the aggregation of supply to the domestic market (from imports and domestic output sold domestically); and the definition of the demand for trade inputs that is generated by the distribution process.

Production is carried out by activities that are assumed to maximize profits subject to their technology, taking prices (for their outputs, intermediate inputs, and factors) as given. In other words, it acts in a perfectly competitive setting. The CGE model includes the first-order conditions for profit-maximization by producers. Two alternative specifications are permitted at the top level of the technology nest: the activity level is either a CES or a Leontief function of quantities of value-added and aggregate intermediate input use.

c. Institutional Block

This block constitutes the modeling of the incomes and expenditures of the four major institutions: households, government, enterprises and the rest of world (ROW). The sources of income for households are factors of production and transfers from other institutions. They use the income for consumption, saving, transfers to other institutions and payment of taxes. Enterprises reveal similar characteristics like that of households in income and expenditure aspects except the absence of consumption in their case. Government uses its income for consumption, saving, and transfers to non-government domestic institutions and to the rest of the world.

d. System constraints blocks

This part is devoted for specification of closures for the model. The closures are set for the government account, current account, saving-investment account and labor market. Even though there are alternative closures for the above accounts and market, the analysis sticks only on those closures which are used by this paper.

Macroeconomic closures

Basically closures are required to set balances on the external, government and saving-investment accounts and labor markets within the economy. For government balance, the chosen closure is that the government savings are fixed but there exists a uniform direct tax rate point changes for selected institutions. This means that this paper raises the level of government savings on education exogenously to meet a desired level of investment on education like 10%, 20% and 30% with the belief that this increment is expected to meet by lifting the direct taxes uniformly for selected institutions. The GAMS file in this paper is divided into two main components as far as the government saving is concerned. The first is the government saving for education and the other partition is the government saving for non-education. This enables the paper to raise the level of government saving on education alone leaving the other to grow at the base level.

As far as the closure on the rest of the world (current account) is concerned, like the government saving, the foreign saving is fixed exogenously to meet a desired level of investment on education and the flexible exchange rate is the adjusting factor to balance the current account. But in the GAMS file employed here, like the government savings, the foreign saving is divided into two parts, i.e foreign saving for education and non-education for the same purpose mentioned above.

Saving driven investment is a closure for balancing saving and investment within the economy. In this regard the saving is changed exogenously to meet a desired level of investment on education. More technically, the quantity of each commodity in the investment bundle is multiplied by a flexible scalar (investment adjustment factor) to assure that the investment cost equals the saving value.

The relevant closure for labor market is that all labor types are unemployed and mobile across sectors. Due to the expansion of higher institutions within the country, it becomes usual to confront with increasing unemployment for skilled workers. As an evidence of this, the Central Statistics Agency (CSA) urban employment and unemployment survey for the year 2011 came up with the finding that unemployment rate for the literate was equal to 20.5% whereas for the illiterate it was 20.2%. Moreover, with the exception of very few sub-sectors that require technical skills, laborers are mobile between the different sectors of the economy. It is not only the supply of labor that is flexible but wage rates too. According to Lofgren et al (2002) if labor is disaggregated, it is possible to make both labor supply and wage rate flexible for each labor type.

Finally since the consumer price index is made to be flexible for poverty and inequality analysis, it is the producer price index set to numeraire.

There are a number of equations that are available in a GAMS for each block of the within model. These equations, since they are bulky, are annexed at the end.

It is worth to note that changes in closures do not have any impact on base simulations but will typically influence the results for other simulations (Lofgren et al , 2002).

Between periods model/dynamism of the model

The already discussed static model has limitations since it does not account for second period considerations for certain policy and non-policy changes

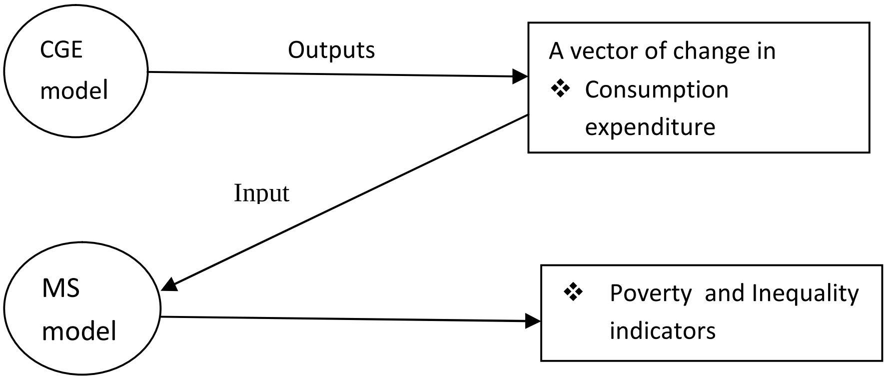
(Thurlow, 2004). More specifically, it does not capture inter-temporal effect of changes in investment and rate of capital accumulation. But in this paper the dynamic aspect of the model is also incorporated on the CGE model to alleviate the problems. In every period the capital stock is updated with the total amount of new investment and depreciation. New capital is distributed among sectors based on each sector's initial share of aggregate capital income. Furthermore, the dynamic model has a room to entertain changes in total factor productivity of production activities. This is done by multiplying either the $\sim_a^{va}$ parameter in the equation below by the percentage change in total factor productivity (TFP), or $¢_{fa}^{va}$ in the case of factor-specific productivity.

$$QVA_a = \sim_a^{va} \left(\sum ¢_{fa}^{va} . (\sim_{fa}^{vaf} QF_{fa})^{-°_c^q} \right)^{-\frac{1}{°_a^{va}}} \quad a \epsilon A$$

It also allows updating the total labor force through not only population growth but also certain policy changes such as increasing expenditure on education via TFP changes.

The recursive dynamic model is calibrated for the 2009/10 Social accounting matrix (SAM) which is an updated version of 2005/06 SAM. Using 2009/10 adjusted SAM enables the paper to entertain economic changes between the period 2005/06 and 2009/10. The model is solved using the general algebraic model system (GAMS) to obtain macroeconomic values.

Consumption expenditure and consumer price index changes obtained from the GAMS are feed to Distributive Analysis Software (DAD 4.6) to know the poverty and inequality impact of increment in educational expenditure. How education expenditure affects poverty is more vividly illustrated by the following diagram.



Source: Daniel, 2011

Educational expenditure projections in GTP

The government planned to spend nearly 156.23 billion Birr in the period of GTP (current prices) with the motto of creating skilled, efficient and effective labor to the realization of Ethiopia's vision of being a middle income economy (MOFED, 2010). Education expenditure is expected to hit a peak value of 44.025 billion Birr in 2014/15 which is twice as compared to the value in the commencement of GTP.

Table 1: Projected education expenditure growth rate for the period GTP

Item	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Average Growth Rate (2010/11-2014/15)
Education expenditures in million birr (projections)	16,870*	21,703	24,562	29,579	36,354	44,025	
Growth rate		28	13	20	22	21	**20.08**

Source MoFED, (2010)

*N.B: * represents actual value*

The growth rate of education is not smooth. It was characterized by a high growth rate in the year 2010/11, low growth rate in 2011/12 and relatively consistent growth rate in the rest of the GTP periods. The average annual growth rate for the period of interest is equal to 20.08%. This value is taken as 20% in this paper to undertake simulations in the forthcoming chapters. This is because the reduced 0.08% has a very small impact when educational expenditure growth rate is converted to an equivalent total factor productivity change.

As far as the means of financing for the above huge educational expenditure is concerned, it is documented in the Education Sector Development Program IV (ESDP IV) where 20% comes from foreign sources and the rest is raised by the government (ESDP IV, 2010).

The empirics of education and total factor productivity

In this paper the approach used to analyze the impact of educational expenditure on the economy is via total factor productivity. More specifically, the desired change on educational expenditure is converted to an equivalent level of total factor productivity so that the work on GAMS (model to solve CGE) would be smooth. To do this, what is required is the elasticity of total factor productivity for a one percentage change in the level of educational expenditure.

An effort was made to determine the elasticity for Ethiopia since there is no such value done before. But the TFP by its nature is affected by a number of variables, which do not have data in the Ethiopian context.

After the first alternative failed, the paper tried to get the value of elasticity between TFP and public educational expenditure from other country/ies which has/have close similarity with Ethiopian in terms of their education and other socio-economic factors.

Lofgren and Robinson (2004) estimated the TFP responsiveness for a 1% change in educational expenditure for sub-Saharan countries and they found it to be 0.06%. Since Ethiopian in the Sub-Saharan category, the paper found it reasonable and justifiable to use this figure. Moreover, the work of Soko Y. (2005) on Tanzania alone (0.06% elasticity between the two variables) is also a supplement and consistent result with the finding of the above estimation.

The analysis consists of four primary simulations. The first among them (base) assumes the continuation of the historical growth trend of 2009/10 for an additional 10 years i.e 2019/2020. The other three primary simulations involve increment of public educational expenditure by 20% financed by the government, foreign savings and a mix of the two.

Table 2: Summary of simulations

Sr. No	Description of simulation	TFP equivalent of education expenditure change
	Base simulation	
1	20% increment in education expenditure financed by government savings	1.2
2	20% increment in education expenditure financed by foreign savings	1.2
3	20% increment in education expenditure financed mix of government and foreign savings	1.2

Finally as discussed above the model employee here allows educational expenditure to affect the economy through factor productivity. In short, the percentage increments of public educational expenditures are converted to an equivalent TFP change to know what impact the former has on the economy.

5. Discussion and analysis

5.1 The impact of expanding educational expenditure on macroeconomic variable

In simulation one (base simulation), the growth rate in real GDP at factor cost is 10.61% on average for the next 10 years. This growth rate is near to the actual growth rate of real GDP at FC in the year 2009/10. The growth rates in absorption, private consumption and fixed investment are 9.39%, 9.56% and 10%, respectively.

Table 3: Macroeconomic impacts (% change from the base)

Variable	Initial (billion birr)	Sim 1 (Base)	Sim 2 (20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (BOTH)
Real GDP at FC	354.95	10.61	2.49	1.74	2.48
Absorption	457.74	9.39	2.08	2.36	2.10
private consumption	338.61	9.56	1.90	2.28	1.92
Fixed investment (non-education)	85.49	10.00	3.20	3.20	3.20
Real Exports	52.14	17.92	3.62	0.24	3.55
Real imports	126.51	11.94	2.61	2.98	2.62
Consumer price index	1.24	-0.11	-0.26	-0.28	-0.27
real exchange rate	1.00	-4.32	-0.96	-1.30	-0.99

Source: simulation results from GAMS

Real growth rate for exports (17.92%) is by far greater than the growth rate of imports (11.94). Exchange rate appreciation decides the fate of the economy if a historical growth trend of 2009 /10 continues for the next ten years.

In the second simulation (increment of public educational expenditure by 20% financed by government saving), the growth rate of real GDP at FC is 2.49 percentage points higher than the base. Absorption, private consumption, fixed investment, exports and imports grow by 2.08, 1.90, 3.2, 3.62, and 2.61 percentage points from the base, respectively. This increment is explained by the injection towards the economy in the form of educational expenditure. Consumer price index decreases by 0.26% from the base. The decrease in CPI is due to the outweighing effect of output increment (Growth rate of GDP at FC) over the tax effect. It should be underlined that the exogenous increase in the level of educational expenditure under this scenario should be financed by the increase in tax on households and institutions. Exchange rate appreciation decides the fate of the economy when the 20% increase in public education expenditure is put on the ground. This is due to the high growth rate in exports and relatively low growth in imports which shifts the supply of foreign currency to the right and in turn reduces the exchange rate.

In the third simulation (increment of public educational expenditure by 20% financed by foreign saving), absorptions and private consumptions grow by a larger magnitude as compare to simulation 2. This is mainly explained by the low tax rate to finance the increase in public educational expenditure in this scenario since the sources are foreign loans and grants. The growth rate in exports is only 0.24 percentage points higher than the base and this growth rate is lower than the growth for exports when the same level of educational expenditure is financed by government savings. This is due the economy's response to the appreciation of the exchange rate (1.3%) that results from capital inflow towards the home country. In response to this appreciation, imports grow by 2.98 percentage points more from the base. The growth rate in real GDP at FC is 1.74 percentage points higher than the base. But this growth rate is lower than the result in the second simulation. This is due to the low growth rate of exports and a high growth rate in imports that are not compensated by growth in absorption, private consumption and investment.

The consumer price index is reduced by 0.28 percentage points taking the base as a reference. This decrement in CPI is higher than the second simulation since the tax element in this simulation is small. One may expect larger decrement in CPI under this scenario than the former due to the small tax but it is not achieved since the growth rate in GDP for this scenario is lower than the former (i.e tax increment raises the CPI whereas the increment in output has the opposite effect).

In the fourth simulation, the results are near to the results obtained in simulation 2. This is because in a combined way of financing, most of the finance source is expected to come from the government savings (80%) and the rest from foreign savings so that this line of financing would be consistent with the plan of the government in the growth and transformation period. Real GDP at FC grows by 2.48% more from the base and it a bit smaller as compared to the result in simulation 2. This reduction is due to the foreign saving component in the combined financing mechanism. The growth rates for absorption and private consumption are a little higher than the simulation 2 for the reason mentioned before. Exchange rate appreciates by 0.99% which in turn fixes the growth rate of exports at 3.55% and imports at 2.62% more from the base.

5.2 Impact of expanding educational expenditure on the labor market

This part is devoted to analyze the impacts of public educational expenditure increments on labor supply /demand (since both should be equal), real wages and factor incomes.

In the base simulation skilled workers (certificates, diploma and above graduates) grow at a rate of 7.6%. The economy also experiences a growth rate of 4.85% and 4.01% for semi-skilled (completed some level of secondary education) and un-skilled (illiterates and those who completed some level of primary education) workers, respectively, for the same simulation.

The supply of skilled, semi-skilled and un-skilled workers increases by 2.49%, 1.38% and 0.83%, respectively, as compared to the base when a 20% increment of public educational expenditure is financed by government savings(see table below). The growth rate for skilled workers is greater than the others and the semi-skilled grow more than the un-skilled. This is because expenditures are incurred for education with the aim of increasing skilled and semi-skilled workers.

Real wage rates increase by 0.25, 0.25 and 0.35 percentage points as compared to the base for the skilled, semi-skilled and unskilled workers respectively. The largest increment in real wage rate goes to the unskilled labor due to the relative scarcity of them when providing education results in larger supply of skilled and semi-skilled workers.

Since the recorded labor supply and real wage growth rates are positive under this simulation, the growth rate for factor incomes is also positive. Labor income grows at a rate of 2.72, 2.03 and 1.94 for skilled, semi-skilled and un-skilled workers, respectively.

Moreover, in the same simulation the income for capital grows at the rate of 2.34 percentage points as compared to the base. This magnitude of change is greater than the change in income for most labor type (semi-skilled and un-skilled). This is because the fixed amount of capital is expected to work with increasing number of workers.

Table 4: Labor market impacts (% change from the base)

Variable	Sim 1 (Base)	Sim 2 20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (20%BOTH)
Labor supply				
Sk	7.60	2.49	0.13	2.41
Ss	4.85	1.38	0.57	1.36
Un	4.01	0.83	0.23	0.78
Real wage rate				
Flab-sk	0.62	0.25	0.51	0.25
Flab-ss	0.19	0.25	0.32	0.25
Flab-un	0.11	0.35	0.39	0.36
Factor incomes				
Flab-sk	8.29	2.72	0.24	2.65
Flab-ss	7.10	2.03	0.84	2.01
Flab-un	10.05	1.94	0.62	1.92
Fcap	9.55	2.34	2.07	2.26

Source: simulation results from GAMS

When the government relies on foreign loans and grants to finance a 20% increment in educational expenditure, labor supply grows at a rate of 0.13; 0.57 and 0.23 percentage points from the base for skilled, semi-skilled and un-skilled workers, respectively. These labor supplies are very much lower as compared to Simulation 2. This is because of the fact that when the government uses its own means to finance the increment in the expenditure, it requires imposing of taxes on households and institutions. Workers respond in two different ways for the above action of the government. They either increase their working hours to compensate for what is lost in the form of taxes or reduce the working hours tempered by low net payments. The increase in labor supply by a relatively higher magnitude in simulation 2 indirectly signals that the workers of this country respond for raising taxes by increasing the working hours. Exposing these workers for the third simulation, they will reduce their working hours since there are no reductions on tax burdens.

Real wage rate grows at a rate of 0.0.51, 0.32 and 0.39 percentage points as compared to the base for skilled, semi-skilled and un-skilled workers, respectively. These growth rates are higher than their counterparts (i.e . financing education expenditures by government savings). This happened because a lower supply of labor in this simulation results in a relatively higher wage rate growth.

When the shift of analysis moves to factor income, the skilled labor income grows by 0.24 percentage points taking the base as a reference. Labor income grows at a rate of 0.84 and 0.62 percentage points for semi-skilled and un-skilled workers in that order.

Income for capital grows by 2.07% as compared to the base. This growth rate is lower than the one recorded in Simulation 2 because in this recent simulation capital is forced to work with a relatively lower number of workers which in turn decreases its marginal productivity. However, the income for capital grows more than the other labor types for the reason mentioned in the former simulation.

In the last primary simulation, labor supply, real wage rate and factor income growth rates are near to the results obtained in simulation 2 (financing of 20% increase in educational expenditure by the government savings). This is because in financing educational expenditure through government and foreign sources, the ratio between them is set in such a way that it would be consistent with the financing desire of the government in the Growth and Transformation Plan. In this period the government plans to finance its expenditure mainly from government sources (80%) and the reaming from foreign sources. That is why labor growth rates are near more to Simulation 2 than Simulation 3. The same explanation is also apparent for real wage and income growth rates.

5.3 Impact of educational expenditure on Sectors of the economy

If we allow the economy to continue its tempo of 2009/10, the average annual real growth rate for agriculture, industry and service sectors are is equal to 7.62%, 10.41% and 13.13%, respectively, for the periods of analysis.

However, growth advances more by 1.66%, 1.26% and 3.11% for the above respective sectors if the government increases its education expenditure by 20% from its own sources. Service sector grows more than the other sectors because among the different sectors of the economy, service becomes as a destination for most of the skilled labor. Under this simulation, the growth rate of skilled labor is greater than the other labor types. In short, since service absorbs much skilled workers, its growth is larger as compared to the others.

When the same level of expenditure is financed by foreign savings (Simulation 3), agriculture, industry and service sectors grow more by 1.79%, 1.14% and 1.77%, respectively, as compared to the base. All growth rates except the growth rate in agriculture are less than what has been recorded in the former simulation. The growth in industry and service is low because of the low growth rate of skilled and semi-skilled workers under this simulation. The reduced supply of unskilled labor in this policy scenario does not affect the growth of agriculture since the sector in LDCs is mainly characterized by the presence of surplus labor.

Table 5: Impacts on sectoral growth rates (% change from the base)

Variable	Sim 1 (Base)	Sim 2 (20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (20%BOTH)
Real growth rate of agriculture	7.62	1.66	1.79	1.68
Real growth rate of industry	10.41	1.26	1.14	1.41
Real growth rate of service	13.13	3.11	1.77	2.99

Source: simulation results from GAMS

In the fourth simulation, the highest growth rate is recorded for the industrial sector as compared to all the preceding simulations. Even though growth rate in labor supply under this simulation lies between Simulation 2 and Simulation 3 as discussed in the above sub topic, growth rate for this sector is the highest. More specifically, the growth rate of the sector in this scenario should not have been more than the growth for the sector in Simulation 2. But it is expected that some workers entered in to negative marginal productivity when labor supply grows at rate of 2.49%, 1.38% and 0.83% for skilled, semi-skilled and unskilled workers, respectively, in the Second simulation. The growth rates in agriculture and service sectors are not a threat in this simulation since their growth is near to simulation 2.

5.4 Impacts of public educational expenditure on welfare

The most important welfare indicator used in the literature for CGE models is equivalent variations. In this specific paper equivalent variations change because educational expenditure affects prices of commodities by increasing the level of output to be produced. Moreover, the different ways of financing the educational expenditure increments has their own impact on prices through taxes and in turn consumption levels. The EV measures the level of income in money terms that the consumer needs to pay before the shock to leave him/her as well off as at the equivalent level of utility loss after the price increases.

In base simulation, EV grows at a rate of 14.37%, 14.51%, 16.11% and 14.61%, respectively, for rural poor, rural non-poor, and urban poor and urban non-poor. In the second simulation, EV change from the base is positive for all household groups. This is because the price decrement due to output growth surpasses increment in taxes to finance the increased educational expenditure.

Table 6: Equivalent variations (% change from the base)

Variable	Sim 1 (Base)	Sim 2 (20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (BOTH)
EV				
Rural poor	14.37	3.55	5.12	3.62
Rural non-poor	14.51	4.47	5.57	4.92
Urban poor	16.11	6.54	6.21	6.54
Urban non-poor	14.61	6.09	5.61	6.08

Source: simulation results from GAMS

In this simulation more utility increments go to the urban poor and non-poor. This happened because the destination of most of the educational expenditure increment is in the urban areas since educational bureaus, secondary schools and universities are located within them.

In the third simulation the equivalent variation increases by 5.12, 5.57, 6.21 and 5.61 percentage points for rural poor, rural non-poor, urban poor and urban non-poor households, respectively. More EV improvements are observed in this simulation for rural poor and non-poor households than in Simulation Two because foreign savings reduce the tax burden of the above households and in turn increase income for disposal. The urban households under this simulation experience improvement in EV but it is less than in the former simulation. This is because even though the tax burden is low, the urban households' labor supply (most of them are skilled) response is low as compared to the former simulation which in turn decreases their factor income.

In the last primary simulation, the improvements in EV are a bit higher than the results collected in simulation 2. This is because the foreign saving component of combined financing is more effective to change equivalent variations especially in the rural area than government savings. That is why we attain higher results in this simulation than the results in simulation 2.

The impact of public educational expenditure on poverty

It is first necessary to discuss the impact of the educational expenditure on consumption expenditure of households to simplify the analysis of the impact of the same on poverty. The level of consumption expenditure improvement signals indirectly the percentage of individuals that should escape from poverty. In the base case scenario, consumption expenditure grows at a rate of 7.56, 7.86,7.79 and 6.61 percentage points for rural poor, rural non-poor, urban poor and urban non-poor households, respectively.

In the second simulation, more improvements in consumption expenditure are observed for all household categories. They grow at a rate of 0.59, 1.10, 1.50, and1.53 percentage points from the base for the above respective households. The improvements are pre-expected because of the additional spending of the government for more employment and advances in wage payments raise the income of the households and in turn consumption expenditures. In this scenario, even though the improvements are for all household categories, more of the changes are for urban poor and non-poor households. This is because the destination of most of the educational expenditure is in the urban centres since secondary schools, universities, educational bureaus are located in.

In the third simulation, consumption expenditure grows at a rate of 1.15, 1.42, 1.34 and 1.22 percentage points from the base. As compared to the second simulation, the rural households show even more improvements in their consumption expenditure under this scenario. This is because the low tax rate in the latter simulation leaves relatively a large amount of income to be disposable for the rural households. But the improvements in the urban households under this simulation are lower than in simulation 2. This is because the supply of skilled labor, where most of them live in the urban areas shrinks due to low tax burden in the simulation 3. This reduces the income of urban households and in turn their consumption expenditures.

Table 7: Impacts on consumption expenditure (% change from the base)

Variable	Sim 1 (Base)	Sim 2 (20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (BOTH)
Consumption Expenditure				
Rural poor	7.56	0.59	1.15	0.61
Rural non-poor	7.86	1.10	1.42	1.12
Urban poor	7.79	1.50	1.34	1.50
Urban non-poor	6.61	1.53	1.22	1.53

Source: simulation results from GAMS

In the last primary simulation, the results obtained are nearly similar to those in simulation 2 because in combined means of financing educational expenditure, the lion's share of the budget should come from government savings so that the way of financing would be in line with the plan of the government in the Growth and Transformation Period. But little improvements in consumption expenditure for rural households are observed in this simulation as compared to the second due to the strong positive effect of foreign means of financing on rural consumption expenditure for the reason mentioned under simulation 3.

The impact of educational expenditure decrement/increment from targeted value on consumption expenditure is not discussed here because its impact can be traced easily when the impact of the same on head count poverty index is dealt with in the following section.

The analysis of impact of public educational expenditure on poverty requires the employment of DAD software. The 2004/05 household income, consumption and expenditure survey of CSA is used as an input data and the base for comparison. The survey covers a total of 21,594 households of which 12,100 are urban and 9,494 are rural. The bottom 40% in each household category are named poor by the social accounting matrix (SAM). This paper sticks to this division for consistency even though the actual head counts deviates from 40% in 2004/05. This level of head count fixes the poverty line to be 1783.06, 1750.4 and 2168.48 Birr for national, rural and urban households, respectively.

The consumption expenditure per adult equivalent, which is obtained from 2004/05 HICE, should be multiplied by consumption expenditure growth in each simulation (including the base) to get a new result for consumption expenditure per adult equivalent in each simulation. It is also necessary to adjust the poverty line in new simulations. This is done by multiplying the old poverty lines listed above by CPI changes in each simulation. The DAD results are discussed in the following section.

In the base simulation, the head count for the nation is equal to 34.36%. Rural poverty is below the national poverty level(i.e it is 34.30%) and urban head counts (35.21%) is above the national level. If we allow the growth trends of 2009/10 to continue for the periods of the simulations, the urban households will experience a higher level of poverty than those in the rural areas.

In simulation 2 head count poverty reduces by 0.5%, 0.38% and 1.08% for national, rural and urban households, respectively. More improvements are obtained for the urban households because as mentioned in the impact of educational expenditure on household consumption section, the urban households have greater chances to receive more of the benefits of public educational expenditures in terms of employment and real wages. Moreover, it is worth mentioning here that the national head count reduction in this simulation is near to the rural level than the urban one (i.e 0.5% approaches 0.38% more than1.08%). This is because most of the people in the country live in rural areas. As a result findings in this area best characterize the findings for the whole nation.

Table 8: impacts on head count index (% change from the base)

Variable	**Sim 1**	**Sim 2**	**Sim 3**	**Sim 4**
Head count poverty	**(Base)**	**(20% GSAV)**	**(20% FSAV)**	**(BOTH)**
National	34.36	-0.50	-0.76	-0.50
Rural	34.30	-0.38	-0.56	-0.39
Urban	35.21	-1.08	-1.12	-1.08

Source: Micro simulation results

In the third simulation national, rural and urban poverty reduces by 0.76%, 0.56% and 1.12%, respectively, as compared to the base. Furthermore, these improvements in head counts are greater than the improvements of the same in simulation 2. This is because the tax burden is low when the government finances its expenditure by foreign savings which leave individuals with relatively a larger amount of income for consumption.

Even though consumption growth for the urban poor and non-poor under simulation 3 is lower than in simulation 2, more improvements in head count obtained in simulation 3 due to relatively larger decrement in consumer price index in this simulation lowers the poverty line.

In the simulation 4, all the results are nearly similar to the results under simulation 2 except for the rural households. The improvement for rural households head count is 0.39% which is a bit greater than the value of the same in simulation 2 (0.38%). The relatively stronger positive impact of foreign saving on rural households' consumption expenditure is the reason behind for this finding.

5.6 Impacts on income distribution

Inequality analysis bases itself on the adjusted consumption expenditure per adult equivalent in each simulation. The best measure to capture inequality within the economy is the Geni- coefficient. It represents the ratio of the area enclosed by the Lorenz curve and the prefect equality line to the area below that line. The value ranges from 0 (prefect equality) to 1 (prefect inequality) or can be expressed in terms of percentages and can vary from 0 to 100%. The higher the level of Geni-coeffiecient, the more severe would be the income distribution. Like the different poverty analyses, the value of the coefficient is calculated using the DAD 4.6 software.

In the base case scenario, the national, rural and urban Geni-coeffiecient are 31.88, 26.73, and 44.03, respectively. More income inequality is the fate of the economy if the growth trends of 2009/10 are expected to continue in the simulation period.

Table 9: Impacts on income distribution (%)

Variable	Sim 1 (Base)	Sim 2 (20% GSAV)	Sim 3 (20% FSAV)	Sim 4 (BOTH)
Geni-coefficient				
National	31.88	31.99	31.90	31.99
Rural	26.73	26.83	26.78	26.82
Urban	44.03	44.03	43.98	44.03

Source: Micro simulation results

In simulation 2, the national, rural and urban households Geni- coefficient are 31.99, 26.83 and 44.03, respectively. In all households inequality increases in this simulation as compared to the base because the growth rate of rural poor household consumption expenditure is below the rural non-poor and is so for the urban households as shown in Table9.

In simulation 3, the national and rural inequalities increase but the urban inequality reduces by a smaller magnitude as compared to the base. The inequality situation in this simulation is better than the previous simulation since foreign saving raises rural-poor income more than the government savings. Moreover, in this simulation inequality reduces for the urban households since the growth of consumption expenditure of the poor is greater than the non-poor.

Finally, in simulation 4, the results are near to simulation 2. If there exists a deviation, it is due to the foreign saving component of the combined financing.

6. Conclusions and Recommendations

6.1 Conclusions

The paper tried to show the economy wide impacts of expanding educational expenditure. The impacts on economic growth, labor supply, welfare, income inequality and poverty were analyzed using a recursive dynamic computable general equilibrium model.

The government of Ethiopia plans to spend the largest of its poverty targeting expenditure on education for the Growth and Transformation Period. Analyzing what corresponding effect it has on the above mentioned economic variables is not an issue of debate since it is of paramount importance.

Expanding educational expenditures beyond the level of 2009 has a positive impact not only in improving economic growth but also in reducing poverty in all primary scenarios employed. However, except for the urban households, educational expenditure aggravates income inequality. When the means of financing is government savings, the maximum economic growth is exploited from the expansion in educational expenditure because labor supply increases more in this way of financing than in other ways. But more improvement is obtained in terms of poverty if the means of financing is foreign savings. This is because the mass (rural) consumption expenditure grows more when foreign means of financing is employed than its domestic counterpart. Moreover inequality is mild if the means of financing is foreign saving.

The results of combined way of financing the desired educational expenditure are very much near to the results of financing them only by government savings. This is because the ratio between government and foreign savings is set at 0.8 and 0.2, respectively, so that they will be consistent with the financing plan of the government in the Growth and Transformation Plan. This high proportion of government dilutes the results of the foreign component. However, the foreign saving component is minimally visible in the growth and rural poverty.

6.2 Recommendations

Improving economic growth and reducing poverty are top agendas of nations everywhere. Among the different sectors, expanding funds towards education enables nations to attain economic growth and reduces poverty simultaneously. It is difficult to get more of such sectors because they either meet the need of economic growth or poverty. The economy grows at its best when the means of financing is government savings. If the desire of the government is to increase growth more than reduce inequality and poverty, the means of financing should look for domestic institutions. On the other hand, poverty is reduced more and inequality is mild when the means of financing is foreign savings. Accordingly, it is possible to optimize gains in terms of economic growth, reduction of inequality and poverty through balancing the mix of financing.

Finally, the economy is more responsive to education budget cuts than increments. Therefore, the government should exert more efforts to avoid reducing budget rather than to increase it.

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Annex

CGE model sets, parameters, variables and equations

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMN(\subset C)$	Commodities not in CM
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CT(\subset C)$	Transaction service commodities
$c \in C$	Commodities	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$f \in F$	Factors
$c \in CDN(\subset C)$	Commodities not in CD	$i \in INS$	Institutions (domestic and rest of world)
$c \in CE(\subset C)$	Exported commodities	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CEN(\subset C)$	Commodities not in CE	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	$\overline{qg}_c$	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG; i ∈ INSDNG)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{if}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity a
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fa}^a	Sector share of new capital
υ_f	Capital depreciation rate	QF_{fa}	Quantity demanded of factor f
Exogenous Variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		
Endogenous Variables			
AWF_{ft}^a	Average capital rental rate in time period t	QG_c	Government consumption demand for commodity
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QH_{ch}	Quantity consumed of commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EG	Government expenditures	$QINTA_a$	Quantity of aggregate intermediate input
EH_h	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c

Symbol	Explanation	Symbol	Explanation
Endogenous Variables - Continued			
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a
$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i (i ∈ INSDNG)
PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_a	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
PX_c	Aggregate producer price for commodity	YF_f	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_a	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of expors	ΔK^{a}_{fat}	Quantity of new capital by activity a for time period t

Model Equations

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \tag{1}$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \tag{2}$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \tag{3}$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}-1} \tag{4}$$

$$QF_{fa} = \alpha_{fa}^{van} \cdot \left(\sum_{f' \in F} \delta_{f'fa}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}} \right)^{-\frac{1}{\rho_{fa}^{van}}} \tag{5}$$

$$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{fa} \cdot QF_{fa} \cdot \left(\sum_{f'' \in F} \delta_{f''fa}^{van} \cdot QF_{f''a}^{-\rho_{fa}^{van}} \right)^{-1} \cdot \delta_{f'fa}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}-1} \tag{6}$$

$$QVA_a = iva_a \cdot QA_a \tag{7}$$

$$QINTA_a = inta_a \cdot QA_a \tag{8}$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \tag{9}$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \tag{10}$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \tag{11}$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{\frac{1}{\rho_c^{ac}-1}} \tag{12}$$

$$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1} \tag{13}$$

$$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_{c'} \cdot ice_{c'c} \tag{14}$$

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \tag{15}$$

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_{cr}^t} \right)^{\frac{1}{\rho_c^t - 1}} \tag{16}$$

$$QX_c = QD_c + \sum_r QE_{cr} \tag{17}$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr} \tag{18}$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \tag{19}$$

$$PM_{cr} = pwm_{cr} \cdot (1 - tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \tag{20}$$

$$QQ_c = \alpha^q_c \cdot \left(\sum_r \delta^q_{cr} \cdot QM_{cr}^{-\rho^q_c} + (1 - \sum_r \delta^q_{cr}) \cdot QD_c^{-\rho^q_c} \right)^{-\frac{1}{\rho^q_c}} \tag{21}$$

$$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_{cr}} \cdot \frac{\delta^q_{cr}}{1 - \sum_r \delta^q_{cr}} \right)^{\frac{1}{1+\rho^q_c}} \tag{22}$$

$$QQ_c = QD_c + \sum_r QM_{cr} \tag{23}$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr} \tag{24}$$

$$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right) \tag{25}$$

$$CPI = \sum_{c \in C} PQ_c \cdot cwts_c \tag{26}$$

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \tag{27}$$

Institutional Incomes and Domestic Demand Equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \tag{28}$$

$$YIF_{if} = shif_{if} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right] \tag{29}$$

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i' \in INSDNG'} TRII_{ii'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR \tag{30}$$

$$TRII_{ii'} = shii_{ii'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \tag{31}$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{ih} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h \tag{32}$$

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma^m_{ch} + \beta^m_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^m_{c'h} \right) \tag{33}$$

$$QINV_c = \overline{IADJ} \cdot qinv_c \tag{34}$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \tag{35}$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \tag{36}$$

System Constraints and Macroeconomic Closures

$$YG = \sum_{i \in INSDNG} \overline{tins_i} \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov,f} + trnsfr_{gov,row} \cdot EXR \quad (37)$$

$$QQ_c = \sum_{a \in A} QINT_{c,a} + \sum_{h \in H} QH_{c,h} + QG_c + QINV_c + qdst_c + QT_c \quad (38)$$

$$\sum_{a \in A} QF_{f,a} = QFS_f \quad (39)$$

$$YG = EG + GSAV \quad (40)$$

$$\sum_{r,c \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} trnsfr_{row,f} = \sum_{r,c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i,row} + FSAV \quad (41)$$

$$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins_i}\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \quad (42)$$

$$MPS_i = \overline{mps_i} \cdot \left(1 + MPSADJ\right) \quad (43)$$

Capital Accumulation and Allocation Equations

$$AWF^a_{ft} = \sum_a \left[\left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot WF_{ft} \cdot WFDIST_{fat} \right] \quad (44)$$

$$\eta^a_{fat} = \left(\frac{QF_{fat}}{\sum_{a'} QF_{fa't}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{ft} \cdot WFDIST_{fat}}{AWF^a_{ft}} - 1 \right) + 1 \right) \quad (45)$$

$$\Delta K^a_{fat} = \eta^a_{fat} \cdot \left(\frac{\sum_c PQ_{ct} \cdot QINV_{ct}}{PK_{ft}} \right) \quad (46)$$

$$PK_{ft} = \sum_c PQ_{ct} \cdot \frac{QINV_{ct}}{\sum_{c'} QINV_{c't}} \quad (47)$$

$$QF_{fat+1} = QF_{fat} \cdot \left(1 + \frac{\Delta K^a_{fat}}{QF_{fat}} - \upsilon_f \right) \quad (48)$$

$$QFS_{ft+1} = QFS_{ft} \cdot \left(1 + \frac{\sum_a \Delta K_{fat}}{QFS_{ft}} - \upsilon_f \right) \quad (49)$$

EXAMINING THE MECHANICS OF SMALLHOLDERS' LOCAL SEED MARKETING SYSTEM: THE CASE OF WHEAT IN SODO DISTRICT, GURAGE ZONE

Shimelis Araya[1]

Abstract

This paper attempts to examine the functioning of local wheat seed marketing system in Sodo district with the specific objectives of identifying the roles and linkage of actors; and distinguishing factors affecting marketable supply of improved local wheat seed. Actors have been evaluated using their structure and performance in the system. The study made use of both participatory approaches (qualitative study) and a household survey to collect the required data. Key informant interviews, observation, and a household survey were conducted. Using a household survey, data was collected from 70 seed producing household heads. A model was designed to estimate the variables that affect local wheat seed supply. Accordingly, family size, mobile, crop income, yield (seed), and price perception are significantly affecting seed supply. To build efficient seed system in local area, farmers should be assisted to establish linkages locally to handle the responsibility of their own seed marketing.

Key words: Actors, Local Seed Marketing, Seed Supply, Sodo District, Wheat Seed

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1. Introduction

1.1 Background of the Study

Improved seed is an important input in all crop-based farming systems, and is a key factor in determining the upper limit of yield (Maredia & Howard, 1998). The seed system involves the whole process of variety development and release, seed production and distribution. To strengthen seed systems, we need to have a comprehensive understanding of them. The seed systems can be either formal or informal (Almekinders, 2000; Weltzien and von Brocke, 2001). The former is externally regulated through the application of rules and regulations governing both production and distribution (Jones *et al.*, 2006; Abebe & Lijalem, 2011).

The formal system has been relatively successful for well–endowed, high–potential areas, but much less successful in more variable and marginal areas. The system does not understand what farmers in these areas need, developing only few, genetically uniform products (Almekinders, 2000; Bishaw *et al.,* 2008). On the other hand, the informal seed system is traditional, semi-structured, and operates at the individual community level, using a wide range of exchange mechanisms, and usually deals with small quantities of seed often demanded by farmers (Sperling & Cooper, 2003; Abebe & Lijalem, 2011).

In Africa, the majority of farmers mainly get seeds from informal channels. These channels contribute about 90-100% of seed supply depending on the type of crop. The informal sector remains the major supplier of seeds of local varieties for many crops grown by smallholder farmers. Due emphasis was given to smallholders' seed production for the purpose of using it as a vehicle for providing resource–poor farmers with improved seeds of modern varieties at affordable prices It was assumed that if seeds of a new variety was made available to seed producers, seeds of that variety would find its way through local distribution channels to many other farmers in the community. (Kibiby *et al.,* 2001; Setimela *et al.,* 2004; Thijssen, *et al.,* 2008).

In Ethiopia, with the aim of overcoming the weakness of the existing seed system, farmers- based seed production and distribution system has been adopted in various parts of the country. The Ethiopian seed enterprise (ESE) contracted farmers in cooperatives to produce and supply seeds agreeing to pay them a price 15% more than the prevailing grain prices at harvest. However, this was optimistic and did not prove to be practical, and the actual seed recovery rate (the proportion of seed actually collected from farmers) is less than 50% (Jones *et al.,* 2006; Dawit 2012). There has been little assessment of factors that affect farmers' local seed marketing in Sodo district of Guraghe zone. Therefore, this paper examines factors that affect local seed supply to locally established cooperatives and the mechanics of local wheat seed marketing and the actors involved in the operation in the study area.

1.2 Objective of the Study

The main objective of the study is to identify factors influencing farmers' supply of local seeds to cooperatives and to examine the functioning of the local seed market in Sodo district, Gurage zone.

Specifically, this study has the following objectives:

- to identify factors influencing farmers supply of locally produced wheat seeds to local seed cooperatives in Sodo district,
- to assess the mechanics (function) of local wheat seed marketing system in the study area,
- to generate conclusive results and policy implications for the development of seed systems in the study area.

2. Literature Review

2.1 The Nature of Seed Marketing

Recognition of the potential of markets as engines of development and structural transformation gave rise to a market led–paradigm of agricultural development during the 1980s that was accompanied by widespread promotion of market liberalization policy agendas in Sub–Sahara Africa (Bellemare & Barrett, 2005; Diao and Pratt, 2006; Barrett, 2007; Boughton *et al.,* 2007). Many smallholders in low–income rural areas opt out of markets largely because of the constraints to access adequate assets and infrastructural facilities (Diao & Pratt, 2006; Samuel & Sharp, 2008).

High fixed costs of entering the seed industry, the public good nature of research in improved varieties, externalities, and problems of information asymmetry on quality complicate seed market development (Abdissa *et al*., 2001; Spielman *et al*., 2011). The problems will vary on the type of crop involved. In case of hybrid maize, the originator can therefore easily exclude farmers from the benefits of the new hybrid if they have not paid for access. In contrast, breeders of wheat may capture few of the benefits because others can easily duplicate the variety without making paying (Abdissa *et al*., 2001; Dawit and Tripp, 2010).

Basically the nature and/or extent of seed demand differ from farmer to farmer. Large- and medium-scale farmers use markets to purchase uniform genetic materials that are highly responsive to chemical inputs rewarded by the market. In contrast, more subsistence-oriented smallholders may value characteristics such as drought tolerance, early maturity or good storage more than fertilizer responsiveness. Smallholders also require small quantities of different seeds as they practise mixed cropping and use the strategy of minimizing production risks by diversifying the variety base.

2.2 Empirical Evidence: Seed Systems in Developing Countries

Cereal grain yields in Sub-Sahara Africa have increased at an average annual rate of less than 0.2% since 1980 (Rohrbach *ea al.*, 2003). One reason for this dismal record might be the limited development of local seed markets. Most farmers still do not have access to commercially processed seed at a nearby center (Rohrbach *ea al.*, 2003). It is rare to find modern varieties bred at research stations and passed to the informal sector for multiplication and sale as an essential part of the national seed policy (Ndjeunga *et al.,* 2000).

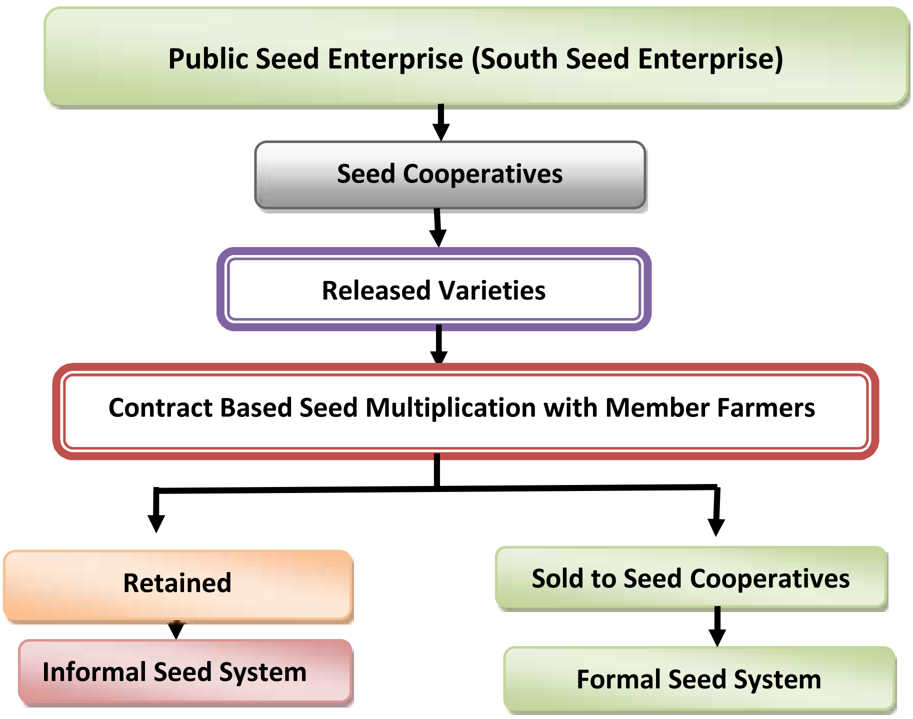
In the region, seed system development varies by country. At one end countries have undeveloped breeding and testing programs which lack seed development policies, strategies, quality control and certification procedures. At the other extreme there are countries (e.g. Kenya and Zimbabwe) which have a promising seed marketing system (CTA, 1999; Kibiby *et al.,* 2001).

Studies conducted by Ndjeunga *et al.,* (2000) in Niger and Senegal on groundnuts and pearl millet, respectively, showed that in the former the state seed producing centers operated with heavy losses (financially unsuitable), and were subsidized. The sector was only supplied a negligible share of the total demand of smallholders. But in the latter, the government gradually decentralized the sector and shifted toward a private mode of seed system.

2.3 The Seed System: Ethiopia

While access to and availability of seed have the potential to greatly improve smallholders' productivity, there was a substantial gap between supply of improved seed and farmers' demand in the country. Currently, some attempts are made to improve seed supply by working in collaboration with farmers. With the support of development partners, farmer seed producers were promoted to boost the development of an integrated seed sector in the country (Sahlu *et al*., 2008; Abebe *et al*., 2011; Dawit, 2011; Dawit, 2012). To this end, the Ethiopian Seed Enterprise contracted farmers to multiply seeds in their plots.

Figure 1: Functioning of Actors in Farmers-Based Local Seed System in SNNPR State



Source: Adapted from Dawit, 2012

Foundation seed comes from the formal system, and subsequent activities are carried out in the informal system. Farmers can produce high quality seed provided they have access to initial improved seed stocks. Such improvement entails transforming the smallholder farmers group into market oriented seed enterprises (Figure 1). The role played by the formal seed sector as a recipient of seed results in cost inefficiency and financial unsuitability (Ndjeunga *et al.,*2000). Changing grain prices tempt farmers to default on their seed supply (Jones *et al.*, 2006; Spielman *et al*., 2011).

The choice of the marketing channel depends on a number of aspects that include availability of markets, prices offered in the market, and distance to the market (Rehima, 2007). Similarly, Samuel and Sharp (2008) identified that the level of farm production, the degree of household dependence on non–farm income, and the age and health of the farmers could affect their ability or willingness to participate in agricultural output markets.

3. Materials and Methods

3.1 Study Area Description

This study was conducted in 2013 in Sodo district, which is bordered by Meskan district in the south and surrounded by Oromia Region in the west, north and east. The district is located between $8^0$10-$8^0$45' North latitude and $38^0$37' - $38^0$71' East longitude. The elevation of Sodo district ranges between 1501 – 2500 masl. The district is administratively divided into 55 kebeles and its administrative center, Buee town, is found 105 km south of Addis Ababa, and around 180 km from Hawassa. According to the National population and Housing Census (BoFED, 2009) result, the population size of Sodo district is around 151,870. The district has a total estimated area of 882 square kilometers and a population density of 172 people per square kilometer.

On average the Sodo district receives a rainfall amount 801 - 1200 mm annually in two rainy seasons: '*belg*' and '*kiremt*'. The district has comfortable soil types for the production of different crops. Mixed farming is the dominant household economic activity in the Woreda. *Enset* (false banana) is the main crop for subsistence, along with for wheat, maize, teff, sorghum, barleyand beans which are also common.

3.2 Sampling techniques and the sample size

A multi–stage sampling technique was used to select sites and draw samples of farmers. Wudigetina Gefersa *Kebele* was selected purposively in the district based on relative number of seed producers, agro-ecological potential of wheat seed production, and accessibility to market. Finally, taking the recommended sample size determination into consideration for a given population (Israel, 1992), 70 households (based on population size, degree of variability, level of confidence and precision) were interviewed for this study. In addition to the interview, the study made use of participatory approaches to supplement the household survey in order to identify constraints in the marketability of wheat seed produced locally.

3.3 Data type, sources and instruments

For this study, qualitative and quantitative data was generated both from primary and secondary sources. To collect primary data, a combination of formal household surveys and participatory approaches was employed. Ellis (2000) indicated that neither sample surveys nor participatory methods, as separate packages, provide a complete approach. Indeed, a combination of the two approaches is required, each serving different but complementary roles within the overall research design. Chambers and Blackburn (1996) defined Participatory Rural Appraisal (PRA) as a family of approaches that enable people to express and analyze the realities of their lives and conditions, as well as to plan what action to take and to monitor and evaluate the results. The most common PRA methods include group discussions, key informant interviews, drawing maps, transect walks, time lines and trend analysis, seasonal calendars, wealth ranking, matrix scoring and ranking, Venn diagrams, and many others (Ellis, 2000). Secondary data was obtained from government and non-governmental offices and previous studies.

3.4 Methods of data analysis

The quantitative data from the household survey was analyzed using both descriptive statistics and econometric analysis. Statistical software SPSS and STATA were used for the analysis. In addition, qualitative data from key informant interviews and observational notes were transcribed, categorized, enumerated, looked for relationships, and interpreted.

Appropriate techniques and procedures were used in the analysis to identify factors that affect farmers' supply of seed. Descriptive statistics were used to provide a summary statistics related to variables of interest. OLS technique was employed for cross-sectional data collected with the help of a household survey. Model misspecification and hetroscedasticity problems were checked by employing RESET and Breush–Pagan tests, respectively.

3.5 Modeling farmer Seed Supply

The study hypothesized that farmers' seed supply depends on observed characteristics of the household including sex and family size, : livestock, crop income, off-farm income, and yield, mobile phone ownership & distance from market; and seed producers' perception of the ESE's price offer (whether it is attractive or not.) Conceptually, the decision model can be stated as follows:

$$\ln(supply) = \beta_0 + \beta_1 sex + \beta_2 famsiz + \beta_3 mob + \beta_4 tlu + \beta_5 crp + \beta_6 off + \beta_7 mkt + \beta_8 price + \beta_9 \ln(yield) + \varepsilon$$

Where ε assumed to be normally and independently distributed $[0, \delta^2)$

3.6 Hypothesis Formulation

A summary description of the explanatory variables used in the model with the expected sign is presented below:

Table 1: Definition of variables, measurements and expected signs

Dependent Variable	**Unit/type**	**Description**
Local Seed Supply	Quintal	Supply of local wheat seed to local seed cooperatives
Explanatory variables		
Variable	**Unit/type**	**Expected sign**
Sex of household head	1 if male, and 0 if not	+
Family size	Number of family members	-
Mobile Ownership	1 if mobile owner, 0 if not	-
Livestock Ownership	Number of livestock in TLU	+/-
Income from Crop	Income from crop sale	+/-
Off–farm income	1 if off-farm income, 0 if not	+/-
Distance from nearest market	kilometers	+
Price Perception	1 if price is attractive, 0 or not	-
Ln (yield_12)	Seed production in 2012 in quintal	+

4. Results and Discussion

4.1 Descriptive Analysis

As indicated in Table 2 below, the survey result revealed that 94.3% of respondents were male. The proportion of female households compared to male households involved in the local seed system is small. This might be due to the fact that the production of improved local seed uses intensive labor force compared to ordinary crop production. In this regard, women lack the capacity to offer intensive labor from land preparation to the process of harvesting in order to produce quality seed. On average, family size for seed producers and suppliers in the study area is about six. Almost 50% of the surveyed households in the study area own mobile phones for personal and business communication.

Table 2: Description and Means of Variables in the Model

Variable	Unit	Description	Mean	Std. Dev.	%
Sex	Binary	1 = Male	---	---	94.3
		0 = Female	---	---	5.7
Family Size	Number	# of HH Members	6. 47	2. 19	---
Mobile	Binary	1 = Having mobile	---	---	48.6
		0 = Not	---	---	51.4
Livestock	Number	# of livestock, in TLU	6. 14	3. 57	---
Crop Income	Binary	1= Having Income	---	---	75.7
		0 = Not	---	---	24.3
Off - farm	Binary	1 = off-farm	---	---	22.9
		0 = Not	---	---	77.1
Market Distance	Number	Distance from Market, km	3. 49	3. 32	---
Price Perception	Binary	1= attractive price	---	---	11.4
		0 = Not	---	---	88.6
Log yield_12	Number	Seed Production in 2012	2. 55	0. 41	---
N = 70					

Source: Household survey result

Regarding the resource ownership and institutional factors of respondents, 75.7% of respondents in the survey have their income from crop sale, and 23% of the households have the opportunity to generate income from off-farm activities. As a rule, seed producing farmers are organized in cooperatives based on their adjacent land free from any contact with ordinary grains in order to produce quality seeds. Therefore, wheat seed producing farmers are located 3.50 km away from the local marketing center in the district. Almost 89% of respondents perceive that the Ethiopian Seed Enterprise (ESE) determined seed price is not attractive. They called for a revision of the local wheat seed price in line with the rising grain price in local markets. Finally, seed producer households surveyed in the study area owned on average 6.14 livestock which is measured in total livestock unit (TLU) terms.

4.2 OLS Estimation

ln (supply)	**Coef.**	**Robust Std. Err.**	**T**	**P>|t|**
Sex of respondent	- 0. 12	0. 14	-0. 90	0. 371
Family size	-0. 06	0. 02	-2. 68	0. 009***
Mobile Ownership	-0. 21	0. 09	-2. 21	0. 031**
Livestock (in TLU)	0. 01	0. 02	0. 29	0. 776
Income from crop	0. 35	0. 14	2. 46	0. 017**
Off-farm Income	-0. 01	0. 09	-0. 02	0. 982
ln(yield_12)	0. 93	0. 10	9. 08	0. 000***
Market distance	0. 01	0. 01	0. 55	0. 585
Price Perception	0. 31	0. 16	1. 86	0. 067*
_cons	-0. 27	0. 60	-0. 47	0. 642

reg lnsupply sex famsiz mob tlu crp_inc off lnyield_12 Mkt PericeP, vce(robust)

Number of obs = 70

F(9, 60) = 49.41

Prob > F = 0.0000

R^2 = 0.8399

The model estimates the variables that affect local wheat seed supply. The model is found to be statistically significant (at P < 0.01) and the explanatory variables jointly explain 84% of the model. The coefficients of sex and market distance possess the expected sign but the observation was not statistically significant. The coefficient of off-farm income agrees with a priori expectations. If a farmer participates in off-farm income generating activities, the farmer is not constrained with cash resources and hence the farmer refrains from supplying seed to locally established cooperatives compared with a farmer without off-farm income.

Family size, mobile, crop income, yield (seed), and price perception are significantly affect seed supply. Having the expected sign, family size affects seed delivery at 1% level. An additional family member reduces supply approximately by 6% (calculated using 100. [exp (β)-1]). This is due to the fact that every additional family member in the household influences the motive for production. For those households having numerous family members, resources are allocated for the production of grains to secure subsistence consumption.

Ownership of mobile phones negatively influence seed supply locally at 5% level. For a given level of other factors, the difference in log (supply) between a mobile phone owner and non-owner is - 0.19. This means that a household who owns a mobile phone is predicted to supply about 19% less, holding other factors fixed. This is based on the assumption that the farmer uses the phone to search other alternative markets that offer better prices compared to a household that does not have the device. As opposed to priori expectations, crop income affects supply positively at 5% level. For the same levels of other factors, crop income earners supply 42% more than those farmers who do not have income from crop sales.

The comparative yield advantage of improved local seed affects farmers' decision to supply positively at 1% level. Moreover, a unit increase in seed harvest (yield) results in 0.93% rise in supply. This is based on the assumption that the better the yield of the improved seed, the higher the demand for the seed and the opportunity to supply more amount of the produce.

Finally, price perception affects seed supply positively at 10% level. If a farmer perceives the price offered by the Ethiopian Seed Enterprise is attractive, he/she is willing to supply 31% more than the supply of a farmer who perceives that the price is not attractive. Farmers become more willing to transfer seeds when they perceive attractive prices are attached to the seeds they are producing.

5. Conclusions

This study has examined the major determinants which affect smallholder farmers' supply of improved local wheat seed in Sodo district of Gurage Zone. The findings revealed that both family size and mobile phone ownership negatively affect local wheat seed supply to local cooperatives. This study also shows that seed yield and income from crop sale positively influence farmers to supply their produce. For the sustainability of the local seed marketing system, diversifying livelihood sources and raising seed production by intensifying or extending efforts could make significant contributions.

Periodic revision of prices in line with the changing conditions in grain markets is needed for improved supply. In the short run, there is a need for effective follow-up and monitoring activities during harvest to raise the seed recovery rate. To build an efficient seed system in local areas in the long run, farmers should be assisted to establish linkages locally to handle the responsibility of their own seed marketing.

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PRODUCTIVITY AND EFFICIENCY OF AGRICULTURAL EXTENSION PACKAGE (CASE OF WOLAITA ZONE)

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Abstract

This study assessed the impact of agricultural extension packages households on the productivity and technical efficiency (TE) of farmers in Wolaita zone. It made use of survey data of 150 full package farmers and 150 partial package farmers. In order to measure the total factor productivity (TFP) differentials, the study used the transitive version of Tornqvist index. Moreover, TE and TGR between full package and partial package farmers in the study area were measured using Stochastic Metafrontier Model (SMFM). Group specific Stochastic Frontier Models (SFM) for full package farmers, partial package farmers and pooled data were first estimated and tested before adopting the SMFM. To identify factors affecting farm level TFP and metafrontier TE the study respectively used ordinary least square (OLS) and Tobit models. Thus, results from the findings showed that partial package farmers are about 69% less in total factor productivity compared to full package farmers showing that engaging in extension package fully has advantages in crop production. However, partial package farmers are found to be more efficient (with TE score 82.9%) than full package farmers (with TE score 55.5%). The calculated mean TGR indicated that full package farmers (96.3%) were more close to the potential output defined by the metafrontier than partial package farmers (88.3%). The mean metafrontier TE level (TE) which was obtained by multiplying*

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TGR by TE scores from the separate SFM, revealed that partial package farmers (73%) once again achieved greater score than full package farmers (53.6%). The implication is that the crop production system of the full package farmers in Wolaita zone is more productive and uses higher technology compared to partial package farmers even though partial package farmers are found to be more efficient compared to crop production system by full package farmers, no matter how differences in endowments and socioeconomics were controlled. The mean TE for the total sample was about 63.5% indicating that crop production in the study area can be further enlarged by about 36.5% if appropriate measures are taken to improve farmers' efficiency status. Results of the OLS regression showed that only non-farm income and distance to market have significant positive effect on TFP differential. The Tobit model also proved the effect of participation on TE to be negative if the farm household-head is full than partial participant. Other variables showing negative signs are household head age, dependency ratio, number of plots and distance to the local market. The "variable non-farm income" was found to impact TE positively. Finally, it is recommended that agricultural support services should direct their efforts not only to make farmers work using higher technology production system but also to assist them efficiently use the available technology attained through these institutional support services.*

Key words: Wolaita Zone, TFP, TE, TGR, Full package farmers, Partial package farmers, SFM, SMFM, Crop Productivity

1. Introduction

Agriculture is the mainstay of the Ethiopian economy accounting for about 41.6% in 2010 (GTP, 2010). This implies that the development of the Ethiopian economy heavily depends upon the speed with which agricultural growth is achieved. In an effort to achieve this growth, the Government of Ethiopia (GoE) has adopted different institutional support services. The

Wolaita Agricultural Development Unit (WADU) was one of such institutions in Wolaita zone which started operation in 1970. Following the 1991 market liberalization, Agriculture Development Led Industrialization (ADLI), was adopted and Participatory Agricultural Demonstration Extension of Technology (PADETS) was introduced. The latter was designed to play a major role in increasing productivity and production of small holding farmers. This program involved establishment of farmer training centers (FTC) to provide information, training, demonstration and advice. PADETS also provided inputs, credit and information on agricultural technology (Alemu et al, 2009).

PADETS, which represents a significant public investment amounting for almost 2% of agricultural GDP per annum, surprisingly generated differing views regarding its impact (David J. Spielman, 2008). Some suggest that despite this huge investment, production and efficiency has increased very little. The extension system also did little to encourage and exploit the inherent resourcefulness of those who work closely with farmers (Gezeheghn et al., 2006). Moreover, extension workers saw their role mostly as distributors of fertilizer and credit rather than technical advisors (Abate Bekele et al, 2006). However, other studies found such services contributed significantly to agricultural productivity in Ethiopia (Alemu et al, 2009).

Despite these studies on the impact of extension programs at national level, little is done to assess the impact the extension program at zonal or/and Woreda level. Moreover, though agricultural extension program has a long history in Wolaita (WADU, 1970), nothing is done to assess its recent development. Hence, the general objective of this study is to assess the impact of agricultural extension packages on the productivity & technical efficiency of farmers in Wolaita zone. Specifically, it assesses the responsiveness of yield to the main factors of production to estimate technical efficiency and to identify determinants of technical efficiency for both fully and partially participating extension farmers.

2. Literature Review

2.1 Total Factor Productivity

At a basic level, productivity examines the relationship between input and output in a given production process (Coelli et al. 1998). Productivity is then expressed in an output versus input formula for measuring production activities. It does not merely define the volume of output, but output obtained in relation to the resources employed. Hence, the analytical framework that handles productivity is theory of production, which postulates a well-defined relationship between output and factor inputs.

Productivity can be conceptualized into two main components, partial factor productivity (PFP) and total factor productivity (TFP). PFP (average product) is defined as the rate of output to a specific input whereas TFP is a ratio of total outputs (measured in an index form) to total inputs (also measurement as an index)[2]. If the ratio of total outputs to total inputs is increasing, then the ratio can be interpreted as indicating that more outputs can be obtained for a given input level. Hence, total TFP captures the growth or changes in outputs not accounted for the growth or changes in factor inputs.

[2] There exist several, often similar, definitions of the rate of change in total factor productivity (TFP) which could lead to different estimates of TFP but ignorable differences.

- The growth rate for the rate of transformation of total input into total output.
- The rate of growth in the real revenue/cost ratio; i.e., the rate of growth in the revenue/cost ratio controlling for price change.
- The rate of growth in the margin after controlling for price change

The advantage of the concept of TFP relies on its ability to explain productivity for the whole inputs used in the production process. Thus the TFP approach is found to be suitable for cases where the complexity and diversity of a production system is large (like the case of smallholder farming in Ethiopia). Moreover, the superiority of the method of TFP over the PFP emerges from the fact that PFP is misleading if there is high substitutability between inputs (Gavian and Ehui, 1996 as cited in Gezahegn et. al., 2006). However, PFP measures are sometimes useful when the objectives of producers, or the constraints facing them, are either unknown or unconventional.

The growth of TFP overtime can result from several factors. First, changes in efficiency: as change in skills in using the existing techniques of production changes productivity; second, when there is variation in scale or level of production overtime: as the output per unit of input varies with the scale of production; and third, technological change which pushes the production frontier upward. Technological change itself can result from quality improvement in input or quality improvements in the production process (like using improved farming practices of production such as ploughs, fertilizers, pesticides, improved seeds).

Lipsey and Carlaw (2003), the most commonly used measures of growth in TFP are growth accounting, data envelopment analysis (DEA) and index number approaches. In growth accounting, we specify a production function that is both stable across time (cross section) and levels of aggregation. The selected aggregate production function is then used as the basis for decomposing economic growth into components attributed to growth in the various input factors. In this method, the growth accounting residual is an index number measure of TFP growth[3].

The Data Envelopment Analysis (DEA) is a special mathematical linear programming model. The DEA approach to TFP growth measurement decomposes changes in TFP into a component that results from a move towards the efficiency frontier (technical efficiency change) and a second component resulting from a shift in the frontier (technological change).

The index number approach uses theory of index numbers. This method is similar to growth accounting approach but does not require specifying a production function. It needs detailed information on outputs, inputs and prices. It essentially measures TFP as a *ration of the index of output to input*[4], whereby a value larger than 1 is considered as resulting from growth in TFP. Laspeyres, Paasche, Fisher and Törnqvist indices are among the commonly used indices in the wide literature of index numbers. The major difficulty with the index number approach is to derive aggregate output and input measures that represent the numerous outputs and inputs involved in most production processes.

[3] Different choices of functional form for the growth accounting decomposition of economic growth by input factor can produce very different empirical results. This can be the case even when the associated growth accounting TFP growth estimates for the different formulas are quite similar. The reason for this is that the TFP growth estimates are not necessarily affected by differences among production functions in the restrictions on interactions among input factors whereas decompositions of growth by input factor are affected by these restrictions think about because the measures are not complicated by choices about how different types of inputs and different types of outputs should be aggregated.

[4] Once we found the output index, Q^{I}_{st} and input index, Q^{I*}_{st} for I any index number type I, TFP growth is $TFP_{st} = Q^{I}_{st}/ Q^{I*}_{St}$.

The Fisher and Törnqvist indices satisfy all axiomatic tests except for circularity (transitivity). These two indices are generally preferred for productivity measurement due, in part, to satisfying index number properties[5]. In practice, the indices yield extremely similar values, especially if computed for periods (cross sections) that are not very far apart.

Moreover, Caves, Christensen, and Diewert (CCD) have converted non-transitive Törnqvist indices into transitive Törnqvist. This property is especially important for cross-sectional data in which one makes pair-wise comparisons for all firms in s and t categories. Suppose we start with Törnqvist indices, Q_{st}^{T} for all pairs, s and t. Then, the transitive Törnqvist indices, Q_{st}^{T} is given by:

$$Q_{st}^{CCD} = \prod_{i=1}^{M}\left[I_{sr}^{T} \times I_{rt}^{T}\right]^{1/M}$$

$$\ln Q_{st}^{CCD} = \frac{1}{M}\sum_{r=1}^{M}\left[\ln Q_{sr}^{T} - \ln Q_{rt}^{T}\right]$$

$$= \frac{1}{2}\sum_{i=1}^{N}\left(\mu_{it} + \overline{\mu}_{i}\right)\left(\ln q_{it} - \ln \overline{q}_{i}\right) - \frac{1}{2}\sum_{i=1}^{N}\left(\mu_{is} + \overline{\mu}_{i}\right)\left(\ln q_{is} - \ln \overline{q}_{i}\right) \qquad \textbf{(1)}$$

Where $\overline{\mu}_{i} = \frac{1}{M}\sum_{j=1}^{M}\mu_{ij}$ is arithmetic mean of output (input) shares for each commodity i (each input i)

$\overline{\ln q_{i}} = \frac{1}{M}\sum_{j=1}^{M}\ln q_{ij}$ is arithmetic mean of each log output i (each log input i) over M

M = number of enterprises (like households, countries, companies etc.) or time periods.

[5] Desirable properties for index numbers include: Positivity: The index (price or quantity) should be everywhere positive; Continuity: The index is a continuous function of prices and quantities; Proportionality: If all prices (quantities) increase by the same proportion, then the index should

In their papers, Caves, Christensen, and Diewert (1982a, b) show that under certain circumstances, the Törnqvist index (which is the discrete counterpart of the Divisia index) is equivalent to the geometric mean of two Malmquist output productivity indexes. Moreover, they show that the Törnqvist index is "exact" for technology that is trans-log (i.e., one can compute a nonparametric productivity index that is "exactly" consistent with the trans-log form). Furthermore, since the trans-log is flexible, the Törnqvist index is "superlative" in the terminology coined by W. Erwin Diewert (Diewert, 1976).

2.2 Technical Efficiency (TE)

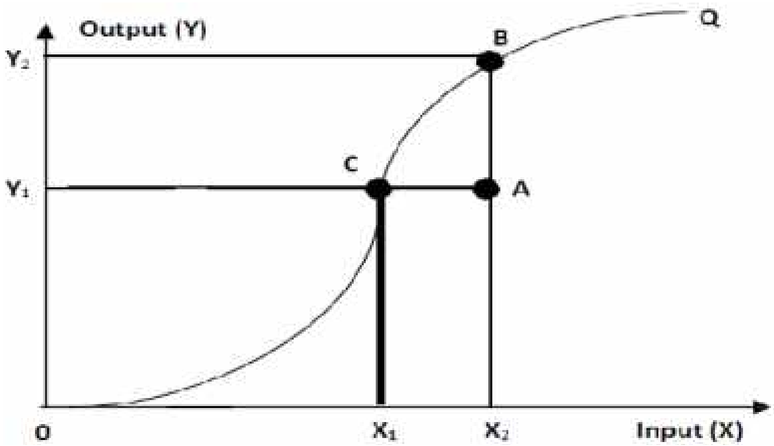
2.2.1 Concepts of Technical efficiency

The concept of efficiency is closely related to that of productivity. While the terms productivity and efficiency are often used interchangeably, efficiency does not have the same precise meaning as productivity does. Efficiency is defined in terms of a comparison of two components (inputs and outputs). The highest productivity level from each input level is recognized as the efficient situation.

In traditional economic theory, efficiency is defined as an outcome of price taking competitive behavior. Thus if no uncertainty is assumed, a production function is described as the maximum level of output that can be obtained from given inputs and the technology available (Kumbhaker and Lovell 2000). However, actual output may typically fall below the maximum that is technically possible. The focus of interest of efficiency in here, therefore, is the deviation of actual output from maximum output.

Coelli, Rao and Battese (1998) further suggest that efficiency reflects the ability of a firm to obtain maximum output from a given set of inputs. If a firm is obtaining maximum output from a set of inputs, it is said to be an efficient firm (Rogers 1998). Mochebelele and Winter-Nelson (2000), as cited in Samuel (2010), also considered technical inefficiency as a measure of management error, rather than income or gross output. Lower inefficiency does not correspond to greater yields or greater income. By applying fewer inputs in a consistent and timely manner, a "low input" farmer, for example, could achieve a better technical efficiency score than a farmer employing more inputs and achieving a higher yield.

Figure 1: Productivity and Efficiency (Coelli, Rao and Battese, 1998)



Efficiency consists of two main components; technical efficiency and allocative efficiency. As discussed above, technical efficiency occurs if a firm obtains maximum output from a set of inputs. Allocative efficiency occurs when a firm chooses the optimal combination of inputs, given the level of prices and the production technology (Coelli, Rao et al. 1998; Rogers 1998). When a firm fails to choose the optimal combination of inputs at a given level of prices, it is said to be allocatively inefficient, though it may be technically efficient. Technical efficiency and allocative efficiency combine to provide overall efficiency (Coelli, Rao et al. 1998). When a firm achieves maximum output from a particular input level, with utilization of inputs at least cost, it is considered to be an overall efficient firm (Coelli, Rao et al. 1998).

As Figure 1 above illustrates, firms which operate at points B and C on the production frontier OQ are considered technically efficient firms. The firm operating at point A is considered inefficient because it could increase its productivity by moving from output Y_1 to maximum productivity at output Y_2. The firm at point C produces output level Y_1 by using a lower input level X_1, while firm A produces the same output level Y_1 by using more inputs. Accordingly, firm A is considered as a technically inefficient firm.

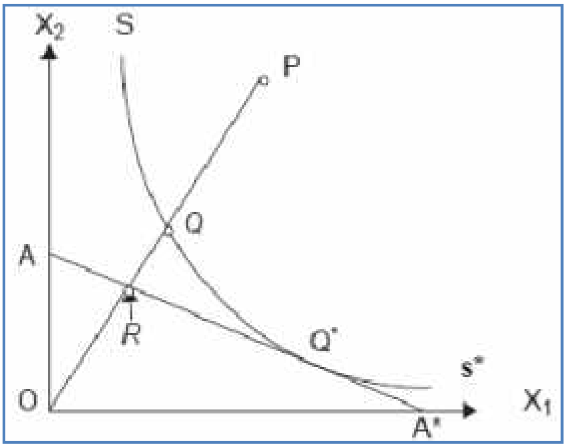
2.2.2 Theoretical Measurement of Technical efficiency

It was Michael J. Farrell in 1957, in his seminal paper, who tried to clearly put theoretical measurement of Technical Efficiency though its measurement dated back to Hicks (1935). Farrell (1957) illustrated efficiency measures with the help of diagrams using input-oriented measures[6] that shows the amount of input quantity that can be proportionally reduced without changing the output quantities.

Figure 2 below presents Farrell's input-oriented measures of Technical efficiency using conventional isoquant and isocost diagrams. Assume a firm which produces output Q, using two inputs X_1 and X_2.

[6] Farrel (1957) also uses Output-oriented measures which tell us the amount of output quantities that can be proportionally expanded without altering the input amounts used. The choice is a matter of convenience as both approaches are expected to give similar measures, at least theoretically.

Figure 2: Technical and Allocative Efficiency (Coelli, Rao and Battese, 1998)



SS* is a set of fully efficient combinations of X_1 and X_2 which produce a specific amount of output Q, an isoquant. Similarly, AA' is a minimum cost input-price ratio or simply an isocost. Now assume that the actual input combination point to produce Q is P. Clearly the firm is experiencing both technical and allocative inefficiencies. Technical Efficiency can be estimated as follows:

$$TE = \frac{OQ}{OP} = 1 - \frac{QP}{OP} \ldots. \qquad \textbf{(2)}$$

It is easy to see from Equation (2) that TE is always between zero and 1. If the firm is fully technically efficient, or if it produces on the isoquant, OP equals OQ which makes the value of TE unity. As technical inefficiency increases, the distance OP increases, which pushes the value of TE towards zero. Though the producer reaches the isoquant and thus achieve technical efficiency, it is producing at a higher cost, above AA*. Hence, Allocative Efficiency for such producer can be defined as:

$$AE = \frac{OR}{OQ} \cdots \qquad \textbf{(3)}$$

By reallocating production in favor of input X_1 and away from X_2, the same output could be produced at even lower cost (at Q*). The idea is that operating at point Q* instead of at point Q and reducing production costs by an amount represented by the distance RQ. Therefore, point Q is only technically efficient but point Q* is both technically and allocatively efficient since the latter lies on the isoquant SS' and on the isocost AA*. The total economic efficiency (EE), therefore, can be defined as:

$$EE = TE.AE = \frac{OQ}{OP} \cdot \frac{OR}{OQ} = \frac{OR}{OP} \qquad \textbf{(4)}$$

The above efficiency measures assume that the underlining production function is known. Therefore, the estimation of the production function is mandatory for the estimation of efficiency measures. Throughout the years, various methods of estimating production frontiers have been developed for the purpose of predicting reliable efficiency measures. These methods vary from deterministic and non-deterministic (stochastic) econometric models to non-econometric models.

The pioneering work of Farrell on efficiency measurement which eventually influenced the development of data envelopment analysis (DEA) using linear programming techniques, is the most popular and well-established non-parametric[7] (non-stochastic) efficiency measurement technique. DEA is

[7] The non-parametric approach does not take statistical noise into account so that all deviations from the frontier is attributed to inefficiency effects only, which consequently provides inaccurate efficiency measures especially in agricultural production (where idiosyncratic and non-idiosyncratic differences are very common).

a performance measurement technique, which can be used for evaluating the relative efficiency of decision-making units (DMU's) in organizations.
The parametric and stochastic approaches[8] are econometric methods developed by various authors for the assessment of productive efficiency. These stochastic parametric methods are the stochastic frontier analysis, the stochastic frontier metaproduction, and the stochastic metafrontier approaches. Battese (1992) indicated that stochastic frontier models better fit agricultural efficiency analysis, given the higher noise usually experienced in agricultural data. The stochastic metafrontier model is a stochastic frontier model designed to incorporate regional and technological differences among firms in an industry.

A. Stochastic Frontier Approach

The stochastic frontier, first introduced by Aigner et al. (1977), was developed to remedy the constraints of deterministic models, mainly the assumption that the production frontier is common to all firms and that inter-firm variation in performance is therefore attributable only to differences in efficiency. Førsund et al. (1980) also stated that such an assumption ignores the very real possibility that a firm’s performance may be affected by factors entirely beyond its control, as well as by factors under its control (inefficiency).

In general terms, a stochastic production frontier can be written as:

$$Q_i = f\left(X_i; \quad \right) e^{£_i} \quad .... \qquad \textbf{(5)}$$

Where: Q_i is output of the individual i = 1, 2 … N

[8] Parametric approach is subject to potential specification error since estimated frontiers and efficiency measures are conditional on the functional form chosen.

f (…) is the production technology; X is vector of N inputs; β is vector of unknown parameter

$\varepsilon_i = (\nu_i - \mu_i)$ is the error term with two components of:

ν_i: is non-negative error term (due to the decision or action of the decision maker)

μ_i: the technical inefficiency component (factors out of control of the decision maker).

$\mu_i = \delta Z_i + w_i$, $\mu_i \geq 0$; where Z_i factors affecting the TE of the decision maker and δ is parameter.

Ordinary least square (OLS) estimation cannot be used to estimate Equation (5), since the composed error term εi = $(\nu_i - \mu_i)$ would be asymmetric and

$$E(v_i - « _i) = E(v_i) - E(« _i) = -E(« _i) < 0 \ldots \qquad \textbf{(6)}$$

Moreover, even if the bias in OLS is somehow resolved, it is not possible to estimate firm specific efficiency scores (Kumbhakar and Lovell, 2000). OLS can only be used to test the existence of technical inefficiency. Since OLS yields inconsistent estimates of the constant term (β_o) and it is impossible to decompose the technical inefficiency from the white noise with OLS, Maximum likelihood (ML) estimation is used to estimate Equation (5).

Estimation of β and μ_i using ML requires a priori imposition of distributional assumptions about ν_i and μ_i. The ML models generally assume a normal distribution with N (0, δ_v^2) for ν_i. On the other hand, there are different assumptions about distribution of μ_i, Half normal, Exponential, Truncated Normal, and Gamma are amongst the most frequently assumed distributions for μ_i. Although different assumptions are made in the literature, Greene (1993) as sited in Sena (2003) suggested that distributional assumption does not affect results very much. Most recent literatures such as Aregie (2001) and Green (2007) pointed out that the half normal distribution is preferred because it provide moderate results in comparison to the other distributional assumptions.

Aigner, et al. (1977) obtained ML estimates under the assumptions that; v_is are independently and identically distributed normal random variables with zero means and variances δ_v^2, v_i ~ iid N (0, δ_v^2). And μ_i s are independently and identically distributed half-normal random variables with scale parameter δ_μ^2 i.e. μ_i ~ iid N^+ (0, δ_μ^2). That is, the probability density function (pdf) of each μ_i, is a truncated version of a normal random variable having zero mean and variance δ_μ^2. μ_i reflects the fact that each firm's output must lie on or below its frontier [f (X_i; β) e^{vi}]. Any such deviation is the result of factors under the firm's control, such as TE. But the frontier itself can vary randomly across firms and on this interpretation the frontier is stochastic, with random disturbance v_i ≤ or ≥ 0, being the result of favorable as well as unfavorable external events.

Aigner et al. (1977) parameterized the log-likelihood function for the half-normal model in terms of

$$Var\ (V_i - \text{«}_i) = \text{¢}_{\text{£}}^{\ 2} = \text{¢}_v^{\ 2} + \text{¢}_{\text{«}}^{\ 2} \text{ and } \text{¥} = \frac{\text{¢}_{\text{«}}^{\ 2}}{\text{¢}_{\text{£}}^{\ 2}}\ ;\ 0 < \text{¥} < 1 \qquad \textbf{(7)}$$

If ¥ approaches zero then either δ_μ^2 approaches zero or $\delta_v^{\ 2}$ approaches to infinity. This occurs if the symmetric disturbance term v dominates the truncated efficiency component μ which in turn indicates that the idiosyncratic error component dominates the inefficiency effects and that OLS estimation techniques are more appropriate than stochastic frontier analysis. As ¥ approaches 1, either δ_μ^2 approaches (δ_μ^2+δ_v^2) or δ_v^2 approaches Zero. And this means that if the variation in the inefficiency component increasingly dominates the variation in ε_i = (v_i - μ_i), it indicates estimating a stochastic production frontier is appropriate. Using this parameterization, the log-likelihood function is:

$$L(Q/\quad ,¢,¥) = -\frac{N}{2}\ln\left(\frac{®¢^{2}}{2}\right) + \sum_{i=1}^{N}\ln\Phi\left(\frac{-£}{¢}\right) - \frac{1}{2¢^{2}}\sum_{i=1}^{N}£_{i}^{2} \qquad \textbf{(8)}$$

Where Q is a vector of log outputs; $\varepsilon_i = (v_i - \mu_i) = \ln Q_i - X_i\beta$ is a composite error term; and $\Phi(x)$ is the cumulative distribution function (cdf) of the standard normal random variable evaluated at X and ¥ is discrepancy parameter that measure deviation. The maximum likelihood estimation of Equation (5) provides consistent estimates for estimator β (output elasticity), ¥ and δ_ε^2. Once we estimate these parameters, Technical Efficiency can be computed as:

$$TE_i = \frac{Q_i}{f(X_i;\quad)e^{v_i}} = \frac{f(X_i;\quad)e^{(v_i - «_i)}}{f(X_i;\quad)e^{v_i}} = e^{(-«_i)} \qquad \textbf{(9)}$$

Where TE_i is Technical Efficiency of the i^{th} firm, the ratio of the actual output to potential (frontier) output, the TE of the i^{th} firm; $f(X_i, \beta)\, e^{vi}$ is the stochastic frontier output.

This TE of firms, which can be predicted using the frontier programs (Frontier 4.1 (Coelli, 1996), LIMDEP (Greene, 2000) or Stata (Stata, Inc., 2012)), is between 0 and 1 and is inversely related to the level of the TE effect. It enables one to know how far each firm's production actually deviates from the frontier production. But this only works when all firms are operating with similar technologies[1]. In reality however, firms in different working environment (countries, region, groups etc.) may not necessarily have similar production technology (Lau and Yotopoulos, 1989). Assuming similar technologies for all when they actually differ may result in erroneous measurement of efficiency by mixing technological differences with group-specific inefficiency (Tsionas, 2002 sited in Otieno et al. 2011).

To avoid such deficiencies of Stochastic Frontier Approach, Hayami (1969) and Hayami and Ruttan (1970) introduced the concept of metaproduction function for the assessment of efficiency. They defined the metaproduction function as "the envelope of commonly conceived neoclassical production functions".

B. The Stochastic Metaproduction

Battese and Rao (2001) showed how technical efficiency scores for firms across regions (groups) can be estimated using a stochastic frontier metaproduction function model, and used a decomposition result to present an analysis of regional (group) productivity potential and efficiency levels. If stochastic frontier models are defined for different regions (groups) within an industry, and for the k[th] region (group), there exists sample data on N_k firms that produce one output from the various inputs.

The stochastic frontier model for this region is specified as:

$$Q_{ik} = f\,(x_{ik};\quad {}^{k})\, e^{\neg_i^k - \ll_i^k}, i = 1,2,...,\ N_k \qquad \textbf{(10)}$$

It is assumed that the v_{ik}s are identically and independently distributed as N (0, δ_v^2) - random variables, independent of the μ_is, which are defined by the truncation (at zero) of the N (0, δ_v^2) - distributions.

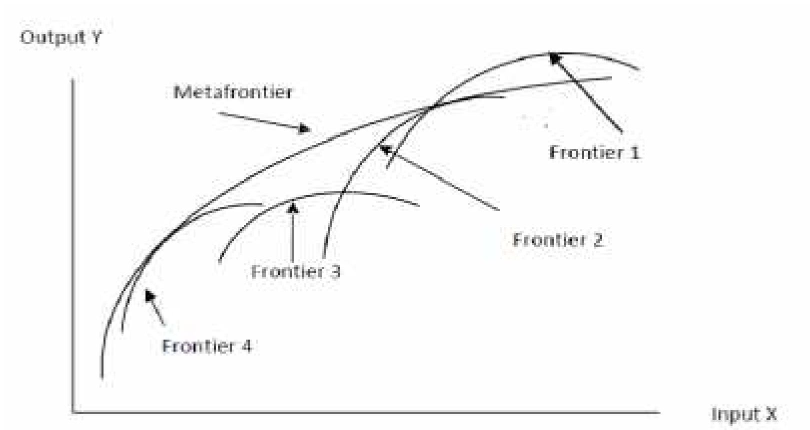
The stochastic frontier metaproduction function model for all firms in all regions of the industry is defined as:

$$Q_i = f\,(x_i;\quad {}^{*})\, e^{\neg_i^* - \ll_i^*}, i = 1,2,...,\ N\ .... \qquad \textbf{(11)}$$

Where $N = \sum_{k=1}^{G} N_k$ is the total number of sample firms in all groups (G).

The maximum-likelihood estimates of the parameters of the above stochastic frontier metaproduction function do not necessarily result in the estimated function being an envelope of the individual regional production functions. This is because if the assumptions for the regional frontiers are satisfied, those associated with the stochastic frontier metaproduction function may not be satisfied (look to Figure 3 Frontier 1 below). However, Battese and Rao (2001) discussed that it is possible to constrainthe estimation of the metaproduction function (Equation (11)) such that it is an envelope of observations for efficient firms in all regions (groups). This method of constraining metaproduction function is called Stochastic Metafrontier (Battese et al, 2004).

Figure 3: Metaproduction Function (Battese et al, 2004)



C. The Stochastic Metafrontier

If we denote i = 1, 2,…, N_k as an index of firms in a group K, according to Battese et al (2004), if inputs and outputs for firms in a given industry are such that stochastic frontier production function models exist for G different groups (k= 1, 2,…, G) within the industry, then the stochastic frontier model for the k^{th} group is defined as:

$$Q_{ik} = f(x_{ik}; \beta^k) e^{V_i^k - U_i^k}, i = 1,2,..., N_k \qquad \textbf{(12)}$$

If the exponent of the frontier production function is linear in the parameter vector, β^k, then the model can be written as:

$$Q_{ik} = f(X_{ik}; \beta^k) e^{(V_{ik} - U_{ik})} = e^{X_{ik}\beta^k + V_i^k - U_i^k} \qquad \textbf{(13)}$$

Battese et al (2004) define the metafrontier function as “a production function of specified functional form that does not fall below the deterministic functions for the stochastic frontier models of the groups involved”. Thus, they expressed the metafrontier production function for all firms in the industry as:

$$Q_i^* = f\left(X_i; \beta^*\right) \equiv e^{X_i \beta^*} \qquad i = 1, 2,...., N \qquad \textbf{(14)}$$

Where f (.) is a specified functional form; Q_i* is the metafrontier output; and β* is the vector of metafrontier parameters that satisfy the constraints:

$$f\left(X_i, \beta^*\right) \geq f\left(X_i, \beta^k\right), \quad for \ all \quad k = 1, 2, ..., G \ ... \qquad \textbf{(15)}$$

According to Equation (15), the metafrontier function dominates all the group frontiers. Given the estimates for the parameters of group stochastic frontiers, $\hat{\beta}^k = 1, 2, ... K$, the $\hat{\beta}^*$ can be estimated by solving the following optimization problem:

$$\min \sum_i^N (\ln f(X_i, \beta^*) - \ln f(X_i, \hat{\beta}^k)$$
$$s.t \ \ln f(X_i, \beta^*) \geq \ln f(X_i, \hat{\beta}^k) \qquad \textbf{(16)}$$

Where $\hat{}^{k}$ is the estimated coefficient vector associated with the group-k stochastic frontier. Since these estimated coefficient vectors are fixed for the above problem, an equivalent form of the LP defined by Equation (16) is:

$$\min \sum_{i}^{N} (\ln f(X_i, \ ^{*})$$
$$s.t \ \ln f(X_i, \ ^{*}) \geq \ln f(X_i, \ \hat{}^{k}) \qquad \textbf{(17)}$$

Furthermore, if the function f (.) is log-linear in the parameters, the LP problem becomes:

$$\min L^{*} = \overline{X} \ ^{*}$$
$$s.t \ X_i \ ^{*} \geq X_i \ \hat{}_{k} \qquad \textbf{(18)}$$

Where $\overline{X}$ is the row vector of means of the elements of the X_i vectors for all observations in the dataset. Any linear programming software can be used to calculate the LP in Equation (17). In terms of the metafrontier, the observed output for the i^th^ farm in the k^th^ production system (measured by the stochastic frontier in (Equation 13)) can also be expressed as:

$$Q_{ik}^{*} = e^{-U_{ik}} . \frac{f(X_i, \ _{k})}{f(X_i, \ ^{*})} . f(X_i, \ ^{*}) e^{V_{iK}} \qquad \textbf{(19)}$$

Where: $TE = e^{-U_{ik}}$ - Technical Efficiency of farmer i relative to its group k and $TGR = \frac{f(X_i, \ _{k})}{f(X_i, \ ^{*})}$ - Technology gap ratio, 0 < TGR < 0.

The TGR measures the ratio of the output for the frontier production function for the k^th^ group relative to the potential output defined by the metafrontier, given the observed inputs (Battese and Rao, 2002; Battese et al., 2004). Values of TGR closer to 1 imply that a farm in a given production system is producing nearer to the maximum potential output given the technology available for the whole industry. The TE of the i[th] farm relative to the metafrontier (TE_i^*) is the ratio of the observed output for the i[th] farm relative to the metafrontier output, adjusted for the corresponding random error such that:

$$TE_i^* = \frac{Q_{ik}}{f(X_i, \quad ^*)e^{v_{ik}}} \qquad \textbf{(20)}$$

Following Equation (19) and (20) can also be expressed as the product of the TE relative to the stochastic frontier of a given group technology and the TGR:

$$TE_i^* = TE_{ik} \times TGR_i \qquad \textbf{(21)}$$

Equation (21) implies that the technical efficiency ratio of the i[th] unit relative to the metafrontier is the product of the TE relative to the stochastic frontier for the given group and the TGR. In other words, the TE scores for units that do not produce under the same technology can be corrected (to make them comparable) using the distance between the group frontier and the leading metafrontier.

2.3 Empirical Literature Review

Ethiopian agriculture is dominated by smallholders. Increasing productivity of smallholders is crucial for the country's economic development. There are two schools of thought regarding development strategies for small-scale farmers in developing agriculture. The first school of thought argues that there are few inefficiencies that exist in allocation of factors of production in peasant agriculture and relays on the development and introduction of new technologies. The second school of thought admits existence of inefficiencies among small scale farmers and puts emphasis on increasing efficient use of existing technologies and resources (Farrel, 1957; Schultz, 1964).

The government of Ethiopia has introduced agricultural extension packages that supported the promotion of modern agricultural technologies to intensify agricultural growth. Extension has diverse definitions but can be summarized as a field where agricultural professionals play a role in identifying, adapting and sharing technology that is appropriate to the needs of individual farmers within diverse agro-ecological and socioeconomic contexts (Landon and Powell, 1996).

Participation of farmers in agricultural extension packages in Ethiopia has been dramatically increased since the introduction of PADETs in 1995/96 EC (Gezahegn Ayele et al 2006). The majority of the farmers in Wolaita zone also participate in agricultural extension package. According to the Central Statistical Agency (CSA), about 85% of the peasants in Wolaita zone participated at least in one of the various crop extension packages during the Meher season of the 2004/05 production year (CSA, 2005). According to the Wolaita zone office of Agriculture and Rural development terminology, those who use all components of extension package in their all crop farming activities are called Full-package farmers and those who use some components of the package in all of their crop farming activities or/and all components of package in some of their crop farming activities are called Partial-package farmers.

Irrespective of such developments regarding agricultural extension package practices, there are only few studies that dealt with the impacts of agricultural extension packages on productivity and efficiency of farmers in Ethiopia.

Arega D. Alene and Rashid M. Hassan (2003) provide the technique of the investigation of technical efficiency of participant and non-participant farmers. They employed a stochastic efficiency decomposition technique that accounts for scale effects to derive the technical efficiency of two samples of farmers, participants and non-participants in Ethiopia's New Extension Program, in two agro-climatic zones in eastern Ethiopia, Babile and Meta. The results in both agro-climatic zones confirm the failure of New Extension Program in enhancing the productive efficiencies of farmers. However, a study by Seyoum et al. (1998) found considerably higher technical efficiency of maize production among participants and non-participants of new Extension Program in eastern Ethiopia.

An empirical study using discriminant analysis of participants and non-participants in an extension package program in Oromia region indicates that the yields of maize and wheat from plots of National Extension Package participants in the study area are found to be as high as 50% for maize and 39% for wheat compared to yields of the same crops from the non-participant farmers, with insignificant difference for Teff and sorghum (Samia and Habe, 2005)

Another study by Gezahegn et al (2006) employed the Tornquvist index to measure Total Factor Productivity (TFP) of Agricultural Extension package participant and non-participants. They found out that average TFP declines for non-extension farmers from that of extension farmers for the majority of sample households for all main crops. Moreover, this study used stochastic frontier model to measure the technical efficiency of extension and non-extension farmers and concluded that Teff and wheat extension farmers are more efficient than the non-extension farmers while this is contrary to the case of maize, where most of the extension farmers are less efficient.

Fantu et al (2011) adopted stochastic frontier analysis using panel data from the Ethiopian Rural Household Survey collected during 1994 through 2009. This study affirmed Participation in the extension program made a moderate contribution towards increases in output. Moreover, average level of farming efficiency for the surveyed farmers across all the years was found to be 46%.

The rest of the studies conducted in Ethiopia in relation to productivity and efficiency are Abrar (1996), Croppenstedt and Abbi (1996), Assefa and Heidhues (1996) and Getu et al. (1998) and applied the stochastic frontier production function model, while Endrias Getaa et al (2010), Abay and Assefa (1997); and Abrar (1995) used a frontier profit function and DEA approaches, respectively.

Abrar (1996) used farm level cross-sectional data from three villages. As per his analysis, technical efficiency variations both between villages and across farmers within a village are observed. Using the same model Croppenstedt and Abbi (1996) showed average level of technical efficiency of farmers in Adaa, Daramalo, Kersa, Shashemene and Yetmen areas was 72% , and sharecroppers were found to be more efficient.

Another study on the level of technical efficiency of small holders in the central highlands of Ethiopia by Assefa and Heidhues (1996) found that there were some opportunities to increase output by improving technical efficiency of farms. Moreover, their analysis shows that fertilized farms were technically more efficient than unfertilized farms. Moreover, Getu et al. (1998), using a stochastic production function, analyzed technical efficiency differentials in Babile District of Eastern Ethiopia and indicated that technical efficiency scores ranged between 20% and 91% in 1991 and between 20% and 100% in 1994.

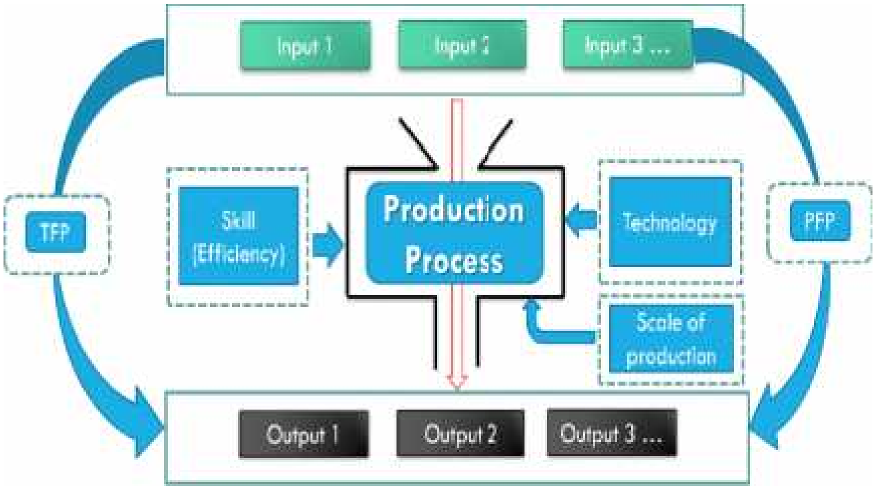
Abay and Assefa (1996) used a frontier profit function approach to examine the impact of education on technical and allocative efficiency of small holders in Ethiopia. The result of the study shows that the mean level of profit efficiency in the sampled farmers was 54%. The study also reveals that educated farmers were relatively and absolutely more efficient than illiterate farmers. Abrar (1995) used DEA to investigate the level of technical efficiency of farmers in three villages in Ethiopia. The result of the study shows that under the assumption of constant returns to scale, the villages exhibited efficiency levels ranging from 39% to 44%. In a similar frame of analysis, Endrias Getaa et al (2010) used a normalized trans-log production function to assess maize productivity in Wolaita and Gamo Gofa zones and found mean technical efficiency of 40% indicating that there was a substantial level of technical inefficiency of smallholder farmers in maize production.

3. Logical Framework

In this study we assume the multi-input and multi-output case in the production process. Moreover, it is assumed that the production process is affected by skill of operators, technology available and scale of production like market expansion.

Advancement in technology induces quality improvement in production process whereas improvements in skill of operators bring change in efficiency of production process. Likewise change in scale of production like expansion of market impacts the production process. When we deal with the productivity and efficiency measures in such framework, total factor productivity (TFP) explains productivity for the whole inputs used in the production process while partial factor productivity (PFP) explains rate of output to a specific input. Thus the productivity (TFP or PFP) will be affected by skill, technology and scale of production.

Figure 4: Input-Output interaction in production Process



4. Methodology

4.1 Data and Sampling

Both primary and secondary data were employed to attain the objectives set. Primary data was collected from sample households through structured questionnaire and secondary data from concerned line offices such as agricultural offices and the Central Statistical Agency.

In this study a two stage sampling procedure is adopted. First, we divide Wolaita zone into eight clusters in a way that encompasses agro-climatic conditions and farming system of the zone. Then, a sample of eight Kebeles were selected first from each cluster using simple random sampling. According to the sampling frame from these eight Kebeles 51% were found to be partial package farmers. Once these Kebeles were identified, we selected a sample of 147 full package farmers and 153 partial package farmers from selected Kebeles proportionally using simple random sampling.

4.2 Method of data analysis

4.2.1 Total Factor Productivity

In this study the transitive Törnqvist indices (Caves, Christensen, and Diewert (1982a)) is used to calculate change in TFP. That is for full-package (t) and partial-package farmers (s):

$$\ln TFP_{st} = [\frac{1}{2}\sum_{i=1}^{N}(\mu_{it}+\overline{\mu_{i}})(\ln Y_{it} - \ln \overline{Y_{i}}) - \frac{1}{2}\sum_{i=1}^{N}(\mu_{is}+\overline{\mu_{i}})(\ln Y_{is} - \ln \overline{Y_{i}})]$$

$$-[\frac{1}{2}\sum_{i=1}^{N}(3_{it}+\overline{3}_{i})(\ln X_{it} - \ln \overline{X_{i}}) - \frac{1}{2}\sum_{i=1}^{N}(3_{is}+\overline{3}_{i})(\ln X_{is} - \ln \overline{X_{i}})] \qquad \textbf{(22)}$$ [9]

$\overline{\mu_{i}} = \frac{1}{M}\sum_{j=1}^{M}\mu_{ij}$ is arithmetic mean of output shares for each commodity (crop type) i

$\overline{3}_{i} = \frac{1}{M}\sum_{j=1}^{M}3_{ij}$ is arithmetic mean of input shares for each input i

$\overline{\ln Y_{i}} = \frac{1}{M}\sum_{j=1}^{M}\ln Y_{ij}$ is arithmetic mean of each log output i over M

$\overline{\ln X_{i}} = \frac{1}{M}\sum_{j=1}^{M}\ln X_{ij}$ is arithmetic mean of each log input i over M and M = number of households

The multiple regressions model is employed to identify the TFP determinants as follows:

$$TFP_{i} = \sim_{i} + \sum_{s=1}^{17}\sim_{s}\cdot_{si} + ¦_{i} \qquad \textbf{(23)}$$

Where: s : s^{th} determinant; i: the i^{th} household (HH); $\cdot_{si}$: Land size (Timad), Labor power (Labor days), Draft power (Timad oxen days), Value of seed (Birr), Value of fertilizer, HH age, HH sex, HH farming experience, HH

[9] We match households from full package and partial package farmers (that have similar input access) using Propensity score matching (Nearest neighbor matching) to calculate the total factor productivity change.

education, Dependency ratio, Distance from farmer training center (FTC), HH nonfarm income, Number of plots owned, Distance to local market (hours), ¦ $_{ik}$: Random error term for efficiency effect model; ~'s: Parameters to be estimated.

4.2.2 Technical Efficiency

The following procedure is used to assess efficiency of the farmers in Wolaita Zone:

1. Specifying production functions for the two groups (Full and Partial package farmers).
2. Estimating stochastic frontier for each group.
3. Performing Likelihood Ratio (LR) tests to determine whether the technological difference between the two categories of farmers was statistically significant.
4. Constructing the metafrontier if the test showed significant difference.
5. Estimating Technology Gap Ratio (TGR) and Metafrontier TE Ratio (TE*).
6. Estimating a Tobit model to verify the determinants of TE* for crop sector as whole.

For this study the Cobb-Douglas model for farmers under Full-package and Partial-package grouping in crop production in Wolaita zone is specified as follows:

$$\ln Q_{ik} = \beta_{0k} + \beta_{1k}\ln X_{1ik} + \beta_{2k}\ln X_{2ik} + \beta_{3k}\ln X_{3ik} + \beta_{4k}\ln X_{4ik} + \beta_{5k}\ln X_{5ik} + V_{ik} - U_{ik} \quad \textbf{(24)}$$

Where: $\ln$: natural logarithm; i: i[th] HH and k the k[th] group (Full or Partial-package); Q : Value of Crop harvest (Birr); X_1 : Land size (Timad); X_2 : Labor power employed (Labor days); X_3 : Draft power employed (Timad oxen days); X_4 : Value of seed utilized used (Birr); X_5 : Value of fertilizer

(Dap and Urea) used (Birr); $'s$: Parameters to be estimated; $U_{ik}\,'s$: Non-negative technical inefficiency component of the error term, assumed to be independent of the $V_{ik}\,'s$ (stochastic noise term) and to follow half normal distribution with mean «_{ik} and variance, $\text{¢}^{2}_{\text{«}}$.

The technical inefficiency effects function (where «_{i} is the mean level of technical inefficiency for household in group k) estimated from Equation (24) can be specified using the following formula:

$$\text{«}_{ik} = \text{¢}_{0k} + \sum_{s=1}^{17} \text{¢}_{sj} Z_{sik} + w_{ik} \qquad \textbf{(25)}$$

Where: s : sth determinant, i the ith household and k the kth group; $U_{ik}\,'s$: Non-negative technical inefficiency component of the error term; Z_{sik} : Socioeconomic & infrastructure variables. w_{ik} : Random error term for efficiency effect model; $\text{¢}'s$: Parameters to be estimated.

The stochastic frontiers for Full and Partial-package farmers were estimated from Equation (23) and (24), using the Frontier 4.1 program by employing a single stage maximum likelihood estimation procedure (Coelli, 1996). Moreover, pooled estimation helped us to determine whether the metafrontier is really necessary for estimating the efficiency levels of the famers. A likelihood ratio (LR) test is calculated to this hypothesis as:

$$LR = -2\left\{ Ln\left[\frac{LH_0}{LH_1}\right]\right\} = -2\left\{Ln(LH_0) - Ln(LH_1)\right\} \qquad \textbf{(26)}$$

Where: Ln (LH_0) = log likelihood functions for the pooled the data, and Ln (LH_1) = sum of the values of the log-likelihood functions for the two stochastic production functions.

If the test statistics is statistically significant, it indicates that the stochastic frontier model for the two groups is different and therefore we need to construct metafrontier. This is done in a way that the estimated function best envelops the deterministic components of the estimated stochastic frontiers for the different groups. Battese et al (2004)'s minimum sum of absolute deviations method is used to construct of the metafrontier as the following linear programming:

$$\begin{aligned} &Min \quad L^{*} = \overline{X} \quad {}^{*} \\ &s.t \;\; X_{i} \quad {}^{*} \geq X_{i} \; \hat{}_{j} \end{aligned} \qquad \textbf{(27)}$$

Where: $\overline{X}$ is the row vector of means of the elements of the vectors for all observations, $\hat{}_{j}s$ are the estimated coefficients of the group stochastic frontiers and * are parameters of the metafrontier function. The TE relative to the stochastic frontier for each group, the technology gap ratio (TGR) and the TE of the i[th] farmer relative to the metafrontier (TE_i^*) are estimated as:

$$TE_{ik} = \frac{Q_i}{e^{\;{}_{0k}+\;{}_{1k}\ln X_{1ik}+\;{}_{2k}\ln X_{2ik}+\;{}_{3k}\ln X_{3ik}+\;{}_{4k}\ln X_{4ik}+\;{}_{5k}\ln X_{5ik}+v_{ik}-u_{ik}|}} = e^{(-U_{ij})} \qquad \textbf{(28)}$$

$$TGR_{i} = \frac{e^{\;{}_{0k}+\;{}_{1k}\ln X_{1ik}+\;{}_{2k}\ln X_{2ik}+\;{}_{3k}\ln X_{3ik}+\;{}_{4k}\ln X_{4ik}+\;{}_{5k}\ln X_{5ik}+v_{ik}-u_{ik}}}{e^{\;{}^{*}_{1i}\ln X_{1ik}+\;{}^{*}_{2ik}\ln X_{2ik}+\;{}^{*}_{3ik}\ln X_{3ik}+\;{}^{*}_{4ik}\ln X_{4ik}+\;{}^{*}_{5ik}\ln X_{5ik}}} \qquad \textbf{(29)}$$

$$TE_{i}^{*} = \frac{Q_i}{e^{\;{}_{0}+\;{}^{*}_{1i}\ln X_{1ik}+\;{}^{*}_{2ik}\ln X_{2ik}+\;{}^{*}_{3ik}\ln X_{3ik}+\;{}^{*}_{4ik}\ln X_{4ik}+\;{}^{*}_{5ik}\ln X_{5ik}}} \qquad \textbf{(30)}$$

$$TF^{*} = (TE_{ik}) \times (TGR_{i}) \qquad \textbf{(31)}$$

The Tobit model had been adopted in determining factors influencing the TE* as Equation (32).

$$TE_{i}^{*} = \bar{}_{0} + \sum_{s=1}^{17} \bar{}_{s} Z_{si} + \ddot{}_{i} \qquad \textbf{(32)}$$

Where: s : the sth determinant and i: the ith household; $TE_i^* s$: Technical efficiency in sector as whole; Z_{si} : Socioeconomic, infrastructure variables and full-package extension participation; ε_i : Random error term and $\beta's$: Parameters to be estimated.

5. Results and Discussions

5.1 Total Factor Productivity

Our estimate for Total Factor Productivity (TFP) based on the Tornqvist TFP Index outlined in Equation 25 (Table 1) revealed on average that TFP falls from full package farmers to partial package farmers by 69 percent. The trend is that in the majority of the matching cases there is a rise in productivity from partial package farmers to full package farmers. We can also see from Table 1 that in about 60 percent of the cases, TFP increases when we move from partial to full package farmers with the majority (57 percent) of these cases with an average of 113 percent increment in TFP (-2< TFP ≤ 0.95). No significant difference is observed in TFP between partial package and full package farmers for 5 percent of the cases. Moreover, in about 34 percent of the cases TFP increases when we move from full package to partial package farmers with the majority (71 percent) of these cases with an average of 141 percent increment in TFP (1.05<TFP ≤ 5).

Looking into the determinants of TFP (Table 2), only household nonfarm income and household distance to the local market are found to significantly affect TFP. Nonfarm income has the expected positive sign assuming nonfarm income supports participation in agricultural extension packages while the unexpected positive sign of distance to the local market may be due to the fact that as farmers are near to the market (mostly recreation center for rural areas), they devote more leisure time.

Table 1: Estimated Total Factor Productivity

TFP Category	*Mean*	*SD*	*Frequency*	*Cumulative Frequency*
TFP ≤ -6	-7.59	0.64	2	2
-6 < TFP ≤ -4	-4.72	0.55	11	13
-4 < TFP ≤ -2	-2.84	0.68	13	26
-2< TFP ≤ 0.95	-0.13	0.76	34	60
*About one**	1.00	0.03	5	65
1.05<TFP ≤ 5	2.41	1.07	24	89
5<TFP ≤ 10	6.49	1.40	8	97
TFP>10	12.22	2.39	2	99

Min: -8.04 Max: 13.91 Mean : 0.31 SD: 3.66
*(0.95 <TFP ≤ 1.05)

Table 2: Determinants of Total Factor Productivity (TFP)

Variable	**Coefficient**	**t - value**
Constant	-2.29	-1.09
Land size (Timad)	0.1883	1.18
Total labor power (labor days)	0.0006	0.07
Total draft power (oxen days)	0.0295	0.89
Total value of seed (Birr)	-0.0004	-0.74
Total value of fertilizer (Birr)	-0.0007	-1.14
Household age	0.0023	0.04
Household sex (1=male)	0.0706	0.06
Household farming experience	-0.0656	-1.02
Household Education(1=illiterate)	-1.0120	-1.03
Dependency ratio	0.5224	1.88
Distance from farmer training center (FTC)	0.0034	0.53
Household nonfarm income (Birr)	0.0002	2.08*
Number of plots owned	0.0229	0.04
Distance to local market (hours)	0.0159	2.36*

N = 99
R^2 = 0.2714
Prob > F = 0.0125
* significant at α=0.05

5.2 Technical Efficiency (TE)

The generalized likelihood-ratio test in Table 3 shows that the claim stating inefficiency components of the total error term of the stochastic frontier model (SFM) specification in Equation (27) equals zero (Ho: $\gamma = 0$) is rejected in all estimation cases (Partial and full package farmers; and the whole sample). This strongly suggests that there was technical inefficiency in the crop sector in the study area. Hence, the SFM specifications are correct.

Table 3: Likelihood-ratio tests of the Hypotheses of Parameters of SFMs

Null hypotheses	*Test statistics (λ)*	*Degrees of freedom*	*Critical value $\chi^2_{0.99}$*	*Decision*
Full package HHs				
H_0: $\gamma = 0$	64.87	18	34.17	*Rejected*
H_0: $\delta_1 = ... = \delta_{17} = 0$	64.94	17	32.77	*Rejected*
Partial Package HHs				
H_0: $\gamma = 0$	66.03	18	34.17	*Rejected*
H_0: $\delta_1 = ... = \delta_{17} = 0$	66.04	17	32.77	*Rejected*
Pooled				
H_0: $\gamma = 0$	98.58	19	35.56	*Rejected*
H_0: $\delta_1 = ... = \delta_{18} = 0$	98.56	18	25.55	*Rejected*

The second claim (H_0:$\delta_1 = ... = \delta_{11} = 0$) that portrays farm level inefficiencies are not affected by socio-economic characteristics included in the model are also rejected in all estimation cases. Thus, the independent variables in our inefficiency models explain the difference in TE. Moreover, the likelihood ratio (LR) Statistic, $\lambda = 46.41 > \chi^2_{0.99}(5) = 14.325$[101], implies the null hypothesis that states that the pooled stochastic estimation is a correct representation of the data, is rejected.

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[10] $\lambda = -2\{Ln(LH_0) - Ln(LH_1)\} = -2\{-294.0 - (-130.9 + -139.9)\} = 46.4$

5.2.1 Estimation of Stochastic Frontiers

We can infer from Table 4 that production inputs of full package farmers except oxen and seed are statistically significant. The unexpected sign observed on the variable labor in full package farmers might arise due to the effect of overcrowded use of labor on small fragmented land. Moreover, inputs labor and fertilizer also had insignificant impact on crop production in partial package farmers but the remaining inputs have affected production significantly.

Table 4: The maximum-likelihood estimates of the SFM, inefficiency effect models and SMFM.

Variable		Full package Households		Partial package Households		Pooled Data		Meta (LP)†
		Coeff.	(t-value)	Coeff.	(t-value)	Coeff.	(t-value)	
Production function								
Constant	β_0	5.6*	8.25	4.45*	7.55	7.36*	10.78	5.930
Ln Land	β_1	0.573*	3.83	0.95*	4.92	0.67*	6.25	0.552
Ln Labor	β_2	-0.274*	-2.06	0.01	0.09	0.002	0.02	-0.137
Ln Oxen	β_3	0.157	1.24	0.37*	2.83	0.124	1.49	0.348
Ln Seed	β_4	0.050	0.47	0.32*	3.47	0.242*	3.847	0.283
Ln Fertilizer	β_5	0.538*	3.98	0.013	1.52	0.163*	1.65	0.186
Return to scale		1.044		1.663				1.232
Sigma Square	$\pm^{2}$	0.466*	5.35	0.371*	6.15	0.42*	9.93	
Gamma	¥	0.465*	4.01	0.15*	2.93	0.149	1.01	
Log Likelihood	LR	-130.9		-139.9			-294.0	
Inefficiency Effect (μ)								
Constant	δ_0	-0.095	-0.08	-1.25*	-3.06	1.49*	2.94	
Age of HH head	δ_1	0.027*	2.58	0.032*	3.07	0.017*	2.59	
farming experience	δ_2	-0.003	-0.28	-0.02**	-1.65	-0.004	-0.51	
HH Edu (illiterate =1)	δ_3	0.376	0.59	-0.001	-0.01	-0.22	-1.25	
HH Edu (Primary=1)	δ_4	0.671	0.91	0.056	0.22	-0.26	-1.61	
HH Edu (secondary=1)	δ_5	0.871	1.26	-0.16	-0.87	0.035	0.24	

Variable		Full package Households		Partial package Households		Pooled Data		Meta (LP)†
		Coeff.	(t-value)	Coeff.	(t-value)	Coeff.	(t-value)	
Dependency Ratio	δ_6	-0.021	-0.25	0.087*	2.53	0.045	1.39	
Extension Experience	δ_7	-0.029	-1.20	0.009	1.57	0.007	1.40	
Distance from FTC	δ_8	-0.011*	-2.74	0.002	1.29	-0.001	-0.66	
No of DA Contact	δ_9	-0.004	-0.60	0.014*	3.53	0.001	0.18	
Livestock (TLU)	δ_{10}	-0.025	-1.42	-0.078*	-2.73	-0.06*	2.83	
Land owned (Timad)	δ_{11}	0.102	0.97	0.211*	2.62	0.09	1.70	
Number of Plot	δ_{12}	0.138*	2.63	0.008*	3.04	0.007*	2.70	
Local market Dist. (Hrs)	δ_{13}	-0.003**	1.77	-0.003*	-3.07	-0.35	-4.32	
Soil type (Chefiama =1)	δ_{14}	0.032*	4.01	-0.0003*	-2.05	-0.0002	-1.623	
Non-farm Income	δ_{15}	-0.0001*	2.14	-0.00004	-1.63	-0.00001	-1.10	
HH Size‡	δ_{16}	-0.0002	-0.003	0.03009	0.41	0.024	0.547	
Credit access (Yes=1)	δ_{17}	-0.118	-0.51	-0.042	-0.34	-0.133	-1.22	
Full package (Yes=1)	δ_{18}					-0.318*	-2.77	

*Significant at α=0.05 **Significant at α=0.1 ‡Measured in Man equivalent

†parameter estimates of the metafrontier function obtained using computer program-Excel Solver.

5.2.2 Estimates of Technical Efficiencies (TE)

Table 5: Frequency Distribution of Summary TE for full and partial package Farmers

Efficiency Score Category	Full Package Farmers			Partial Package Farmers		
	Mean	Frequency	Percentage	Mean	Frequency	Percentage
Mean	0.555			0.829		
Standard Deviation (SD)	.205			0.231		
TE > Mean		79	53.74		97	63.40
Total	147			153		
Maximum	0.949			1		
Minimum	0			0.174		

Table 5 reveals that the mean TE of partial package farmers is about 83 percent, ranging from 17 to 100 percent. Similarly, full package farmers have a mean TE of nearly 56 percent ranging from 0 to 95 percent.

5.3 Estimates of Metafrontier Technical Efficiencies and Technology Gap Ratios (TGR)

In the search to find out whether full and partial package farmers in Wolaita zone are currently operating using similar technology, the log likelihood ratio test indicates failure to accept this presumed hypothesis. Now there is the green light to apply metafrontier methodology for the analysis of TE of full and partial package farmers. Parameter estimates of the metafrontier production function (β^*) are estimated solving the linear programming problem in Eq. (30) using Excel Solver.

Accordingly, partial package farmers have the lowest mean TGR, 0.88 (Table 6). This simply indicates that, even if farmers under this category attain the maximum technology available for the group, they will still be about 12 percent away from the output that they could produce if they used the maximum technology available in the whole sample. On the other hand, as shown in Table 6, full package farmers have the highest technology compared to partial package farmers (with mean TGR of 0.963). However, even in such circumstances, the potential improvement in output relative to each best technology available for full package farmers and relative to the best technology available for all groups is around 45 percent. Moreover, the mean metafrontier TE (TE*) for the total sample equals about 63.5 percent.

Table 6: Summary Statistics for TE, TGR and Metafrontier level Technical Efficiencies (TE*)

Group	Variable of Interest	Mean	SD[ǂ]	Maximum	Minimum
Full Package Farmers	TE	0.555	0.21	0.949	0
	TGR	0.963	0.03	1.00	0
	TE*	0.536	0.20	0.913	0.726
Partial Package Farmers	TE	0.829	0.23	1	0.174
	TGR	0.88	0.04	1	0.754
	TE*	0.730	0.20	0.942	0.140
Pooled	TE	0.695	0.26	1	0
	TGR	0.922	0.05	1	0.726
	TE*	0.635	0.22	0.942	0

*TE from Meta Frontier Analysis [ǂ]Standard deviation

Tobit Model to Verify the Determinants of Technical Efficiency

The results presented in Table 7 signify that age of house hold head, and education, dependency ratio, frequency of DA contact, land fragmentation (number of plots), household distance from local the market, soil type, non-farm income and full package participation explain technical efficiency of crop production in Wolaita zone. The negative coefficient of the dummy for full package participation confirms that full package farmers are, on the average, indeed less efficient than the partial package farmers. This finding perfectly supports our previous finding that partial package farmers score higher mean TE than full package farmers both when it is measured with reference to their group-specific and Meta technology maximal output level.

Table 7: Tobit Model Estimation of Metafrontier Technical Efficiency Effects

Dep. Variable – TE*	**Coefficient**	**t - value**
Constant	*1.10**	*13.85*
Age of HH head	*-0.006**	*-4.46*
farming experience	*0.002*	*1.59*
HH Edu (illiterate =1)	*-0.119**	*-2.24*
HH Edu (Primary=1)	*-0.113**	*-2.23*
HH Edu (secondary=1)	*-0.197**	*-3.59*
Dependency Ratio	*-0.015**	*-1.70*
Extension Experience	*0.001*	*0.60*
Distance from FTC	*0.0001*	*0.69*
No of DA Contact	*-0.002**	*-2.79*
Livestock (TLU)	*0.004*	*1.52*
Land owned (Timad)	*-0.015*	*-1.63*
Number of Plot	*-0.063**	*-3.03*
Local market Dist. (Hrs)	*0.0004**	*2.17*
Soil type (Chefiama =1)	*0.08**	*2.95*
Non-farm Income	*0.00001**	*3.89*
*HH Size*ᵠ	*-0.004*	*-0.41*
Credit access (Yes=1)	*0.026*	*1.27*
Full package (Yes=1)	*-0.154**	*-6.63*

Pseudo R^2 = - 4.4792, *sigma = 0.1621492* ** significant at α=0.05*

ᵠ*In man equivalent*

Furthermore, the negative sign on education and number of plot shows that technical efficiency of the whole sample can be improved if households become educated up to higher level education and possess plots located in one area. And as age of house hold head, dependency ration and frequency of DA contact increased whole sample TE decreases. Though not significant in magnitude, increment in non-farm income and residing further away from local markets increases TE.

6. Conclusions and Recommendations

This study tried to examine the productivity and efficiency impact of agricultural extension packages using a sample of 147 full package agricultural extension farmers and 153 partial package agricultural extension farmers selected from eight Kebeles representing agro-climatic conditions and farming system of the zone. We employed Törnqvist index to look into the Total factor productivity (TFP) differentials between partial and full package farmers and stochastic metafrontier approach to investigate the Technical Efficiency (TE) scores and technology gaps (TGR) of aggregate sample after Cobb-Douglas stochastic frontier model for each household group, and pooled data were first estimated using a single stage maximum likelihood procedure and needed test were undertaken.

Results from TFP analysis indicate that about 60 percent of full package farmers have TFP greater than that of the partial package farmers, implying that on average TFP declines from full package farmers to partial package farmers for the majority of sample households. This has an overall implication that adopting technologies of agricultural extension package fully have brought about substantial difference in productivity between partial and full package farmers. The ordinary least square regression also pinpoints that TFP differentials are only significantly affected by non-farm income and household distance to the local market. Hence, implementers should strengthen their efforts to broaden full participation of farmers in agricultural extension packages.

Similarly, results of separate stochastic frontier maximum likelihood estimations show that there is variability in crop output in both groups induced as a result of technical inefficiency of the producers (γ value of 46.5 and 15 percent for full package and partial package farmers respectively). This indicates that both groups of farmers have considerable overall productive inefficiencies (mean TE of 0.56 and 0.83 for full package and partial package respectively) suggesting the existence of immense potentials for enhancing production through improvements in efficiency with the available technology and resources.

As far as the inefficiency effect models analyses are concerned, being headed by older age, possessing land which is of chefiama soil type, and having fragmented land significantly increases inefficiencies of full package farmers. Full package farmers' inefficiency can be reduced if farmers of this category rise their non-farm income. On the other hand, inefficiency of partial package farmers can be significantly reduced as their livestock holdings and household head farming experience are increased. Moreover, frequency of contact with development agents (DA), age of household head, dependency ratio, and number of plots owned and size of land possessed are factors that significantly increase inefficiency of partial package farmers.

The stochastic frontier maximum likelihood estimation also showed that both groups of farmers operated under different technologies (as per likelihood ratio test). This indicated that efficiency estimations that fail to take into account such technology differentials could lead to biased results. Hence, the stochastic metafrontier analysis is used to analyze TE of farmers with heterogeneous technologies.

Thus, the result from the stochastic metafrontier estimation revealed that full package farmers on average attain higher crop production potential defined by the metafrontier (with mean TGR of 0.963) compared to partial package farmers (with mean TGR of 0.88). Estimation of metafrontier TE (TE*) scores also showed that partial package farmers are less inefficient in crop production compared to full package farmers (with TE* of 0.73 and 0.54, respectively) no matter how resource endowments and socioeconomics differences were controlled.

Moreover, the mean metafrontier TE (TE*) for the total sample equals about 63.5 percent, which indicates that crop production in the study area can be further enlarged by about 36.5 percent if appropriate measures are taken to improve farmers' efficiency status. The Tobit model estimation also shows that relationship between age of household head, and education, dependency ratio, frequency of DA contact, land fragmentation (number of plots) and full package participation (except household distance from the local market, the dummy for soil type and non-farm income) and the technical efficiency scores are negative.

This implies that, though farmers fully engaged in agricultural extension packages are more productive (found at higher production technology), they are not efficiently using their existing production potential compared to partial package farmers.This paper therefore recommends that agricultural support services should direct their efforts not only to make farmers work in higher technology production system but also to efficiently use the available technology attained through these institutional support services.

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