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The Determinants of Technical Efficiency of Farmers in *Teff*, Maize and Sorghum Production: Empirical Evidence from Central Zone of Tigray Region

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Abstract

This study is made to examine the technical efficiency of farmers in Teff, Maize, and Sorghum production in the Central Zone of Tigray. The study used primary data collected from a sample of farm households selected using a combination of probability and non-probability sampling techniques in the 2014 cropping season.

A single step stochastic frontier production model is used for Teff, Maize, and Sorghum production separately. Based on the regression output of the stochastic frontier models, there is no evidence of technical inefficiency of farmers in the production of Sorghum. Evidence of technical inefficiency is found in the production of Teff and Maize though the predicted level of inefficiency in Teff is infinitesimal (less than 1%). Therefore, the deviation of actual output from the frontier output in Teff and Sorghum production is the result of the stochastic factors beyond the control of the farmers such as bad weather, drought, and the like. The reason behind low level of output in Sorghum and Teff production is not technical inefficiency of farmers but the low level of the current technology available to the farmers. Therefore, increasing output in these two crops requires shifting the current level of technology. Only farmers in Maize production are found to be technically inefficient with a predicted possibility of 4.5% efficiency gains. The technical inefficiency of farmers in maize production significantly differs across the three Woredas; Werie-Lekhe with the highest

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inefficiency of about 11% followed by Lailai-Maichew and Kola-Temben with inefficiencies of 6% and 0% respectively.

The low level of technical inefficiency in Maize, bare evidence of inefficiency in Teff and the nonexistence of inefficiency in Sorghum production are against the preceding evidences. This might be due to the difference in the choice of the dependent and explanatory variables. Moreover, the farmers might have improved their input use over the last couple of years due to training and extension services. Moreover, labor input measured in man days is found to be positive and significant in contrast to the preceding evidences implying agriculture in the study area not subjected to excess labor with zero or negative marginal productivity.

Finally, suboptimal technology adoption [the use of fertilizers below or above the standard amount required] doesn't affect output in Teff and Sorghum production but it tends to reduce output in Maize production. Moreover, training on modern input use, access for credit, the dummy for main crop, and irrigation are found to be significant determinants of technical efficiency in Maize production. Therefore, farmers should use the standard amount of fertilizer in Maize production and specialization is superior to diversification in all crops.

Key Words: Technical Efficiency, Stochastic Frontier Model.

JEL Code: Q12

1. Introduction

1.1 Background

Rain fed, subsistence level, small land holding, and retrograde production technology characterize the agricultural sector in the Ethiopian economy. According to Zenebe and Yesuf (2013), significant portion of the population depends on food aid despite encouraging growth in agricultural production in recent years. Food aid has been about 10% of domestic food production in the last two decades and 10% of the population had been food dependent in the year 2009.

Despite the tremendous development endeavours towards the MDGs in recent years, Ethiopia is among the poorest countries, MoFED (2012), on its interim report on poverty analysis, has shown the existence of rural-urban and regional disparity in poverty indices in Ethiopia. As per the report, Tigray is among the poorest regions in the country with head count ratios of total poverty and food poverty reported to be 31.8% and 37.1% respectively. These figures are well above the national averages of 29.6% and 33.6% respectively. Moreover, the region has registered head count ratios of 36.5% and 40.2% in terms of total poverty and food poverty in the rural areas. These figures surpass the national averages of 30.4% and 34.7% respectively as well.

On top of the regional disparity in poverty, there is also huge regional disparity in crop productivity as well. Maize, Sorghum and *Teff* are among the major cereals produced in the country. According to the CSA Agricultural sample survey (2013/14), the region's productivity in *Teff* and Maize are found to be 13.30 qt/ha and 22.79 qt/ha which are well below the national averages of 14.65 qt/ha and 32.54 qt/ha respectively. The region's productivity in Sorghum is found to be 25.4 qt/ha which is higher than the national average of 22.83 qt/ha. The survey also indicates zonal disparity in the productivity of crops within Tigray region. The Central zone is found to have lower crop yields of 19.54 qt/ha and 17.22 qt/ha in Maize and Sorghum respectively which are much more below the regional averages. However, the zone is found to have better productivity of 13.43 qt/ha in *Teff* production and is a touch higher than the regional average.

Different evidences have also shown that Tigray is one of the most inefficient regions in cereal production. For instance, Gezahegn *et al*. (2006) revealed that technical inefficiency of farmers in the production of *Teff*, Maize, and Wheat in Tigray was estimated to be 35% and was higher than that of Amhara, SNNPR, and Oromia with estimated inefficiencies of 29%, 19%, and 10% respectively. Similarly, Shumet (2012) had also revealed that the average efficiency of farmers in crop production is estimated to be 60% which indicates a need for about 40% improvement. Gebrehaweria *et al*.

(2012) also estimated average technical efficiency of rain-fed and irrigated farming to be 82% and 45% respectively.

Based on the above reports and empirical evidences, the incidence of food poverty in Tigray might be attributed to low level of agricultural productivity which in turn might be affected by improper input usage, soil infertility, drought, low access for irrigation, low efficiency in production, and the like.

This study is, therefore, designed to investigate whether there is input use inefficiency of *Teff*, Maize and Sorghum producers in the Central Zone of Tigray using data collected from farm households. A single step stochastic frontier model is estimated in the outset and the level of technical efficiency of the farmers is predicted.

1.2 Research Questions

The study is mainly concerned with estimating the level of technical efficiency of farmers and the determinants of technical efficiency. Suboptimal technology adoption, extension services, and sex are among the major determinants chosen by the author. Suboptimal technology adoption might have positive or negative impact on technical efficiency depending on its nature. If farmers sub-optimally adopt technology (use fertilizer below or higher than the standard) because of failure to afford prices, it might negatively affect efficiency otherwise not. The author has also given special attention to extension services and sex as a policy variable and gender issue respectively. Therefore, the following research questions are developed in this study.

- How much technically efficient are farmers in Maize, Sorghum, and *Teff* production?
- How does suboptimal technology adoption affect the technical efficiency of farmers?
- How do policy variables such as extension programs affect the technical efficiency of farmers?

- Is there a gap in technical efficiency between female headed and male headed farm households?

1.3 Objectives of the Study

The general objective of the study is to examine the technical efficiency of cereal production and the determinants of technical efficiency of farmers in the study area.

Specific objectives of the study are:

- To estimate and investigate technical efficiency differences of farmers
- To examine the factors affecting the technical efficiency differences of farmers

1.4 Research Hypothesis

Based on the research questions posed, the author has developed the following hypotheses:

- At least one farmer is technically inefficient in *Teff*, Maize or Sorghum production
- Suboptimal technology adoption is expected to have negative impact on technical efficiency because using fertilizers below or above the standard required is more likely to reduce output
- Policy variables such as extension programs are expected to have positive impact on technical efficiency of farmers
- There exists efficiency gap between female headed and male headed farm households

1.5 Significance of the Study/Contribution to Current Literature/

For a country of highly agrarian based economy, high population growth rate, and significant number of food insecure population. Ethiopia, research findings on agriculture and food production are crucial inputs for decision making. For the ever mounting nature of food demand and food items' prices in the country, increasing the productivity of farmers has indispensable contribution to solve the problem. Increasing productivity of farmers is possible through the implementation of sound agricultural policies and strategies. The effectiveness of the policies in turn is promising if they are backed by researches and empirical evidences.

This research has its own contribution to policy makers in terms of identifying the nature of the most inefficient farmers and identifying the socio-economic and policy variables that have significant effect on efficiency of farmers. This would help them recognize future policy concerns and devise sound agricultural policies. On top of this, it can be used as a benchmark study for comparisons with improvements attributed to the second cycle Growth and Transformation Plan period. The research can also be used as a reference material for those who are keen to do researches on similar areas in the future.

Moreover, the research has its own contribution to the existing literature. Different researches have been done in Ethiopia and Tigray in a similar topic. Although, some of the researches done in other regions of Ethiopia are done at zonal levels, the researches done in Tigray are conducted at regional level. These regional level research findings might suffer from small sample sizes which might not represent the characteristics of farmers all over the region. Therefore, this research can solve the problem of sample size by increasing the sample size and improve the representativeness of the sample by focusing at Zonal level analysis. Moreover, there is a difference on the choice of explanatory variables and hence the structure of the models in this research and the previous researches done in Tigray region. For instance, the variable “compulsory technology adoption” was not used; the input variables of pesticides and insecticides were not used in the previous researches. Moreover, the dependent variable was taken as a market value of all crops whereas this study uses the physical quantity of each crop as dependent variable.

2. Literature Review

According to Page (1980), Shih *et al*. (2004), and Zamorano (2004), technical efficiency is defined as producing the maximum possible amount of output using a given sets of inputs or producing a given level of output using minimum possible combinations of inputs. In a world of scarce resources, especially in the developing countries, technical efficiency in production is indispensable.

According to Farrell (1957), efficiency can be explained in terms of technical efficiency, allocative efficiency and economic efficiency. Technical efficiency refers to the minimum combination of inputs required to produce a given level of output. Allocative efficiency refers to the least cost combination of inputs required to produce a given level of output. Determination of allocative efficiency, in this case, requires knowledge of the market prices of all inputs used in the production process. A technically efficient way of production is not necessarily allocatively efficient and an allocatively efficient way of production is not necessarily technically efficient. If the production method is both technically and allocatively efficient, we call it economically efficient.

According to Abate *et al*. (2013), poverty alleviation and ensuring food security of small holder farmers is possible through augmenting productivity and commercialization. Improving productivity of small holder farmers can be achieved through better access to technology and extension services. Extension services enhance productivity of farmers through improving technical efficiency of farmers.

The stochastic frontier production model has been widely used to estimate the technical efficiency of farmers in agricultural researches. Several technical efficiency/inefficiency researches have been conducted in Ethiopia and other countries. For instance, Bamlaku *et al*. (2007) have analyzed technical efficiency of farmers in three ecological zones in Ethiopia. Access to credit, literacy, proximity to market and livestock are found to have positive and significant effect while age, sex, extension service and off-farm activities are found to have insignificant effect on technical efficiency of farmers. Moreover, Endrias *et al*. (2012) have examined technical efficiency of maize farmers in Wolaita and Gamo Gofa zones. Based on their estimation, agro-ecology, oxen holding, farm size and use of improved maize variety are found to be significant whereas age, education, family size and access to credit are found to be insignificant determinants of technical efficiency.

Different researchers have also examined technical efficiency of small holder farmers in Tigray region. For instance, Zenebe and Yesuf (2013) and Shumet (2012) have examined technical efficiency of farmers in the region. Moreover, Gebrehawaria *et al*. (2012) have estimated technical efficacy of farmers in irrigated lands and rain-fed lands. Based on the findings of Zenebe and Yesuf (2013), off farm participation (negative) and irrigation (positive) are the only variables to have significant effect on the technical efficiency of farmers while gender, age and education are found to be insignificant.

Shumet (2012) revealed age, education, household size, and credit as positive and significant determinants whereas livestock and off-farm activity as negative and significant determinants of technical efficiency of farmers. Moreover, irrigation and gender are found to have no significant effect on technical efficiency of farmers. Gebrehawaria *et al*. (2012) found access to credit, literacy, road distance as negative and significant variables whereas age as insignificant variable in determining technical efficiency.

As we can see from the above empirical evidences, the effect of some variables such as education, age credit and extension services is found to be indefinite; a mixture of positive and insignificant effects. However, the basic problem of the researches is the choice of the dependent variable and the input variables. All of the above researches except Endrias *et al*. (2012) have used the market value of all crops produced by farmers as the dependent variable. This might lead us to a wrong conclusion because technical efficiency of farmers can differ by crop type. Therefore, crop specific technical efficiency is more plausible than a combination of all crops in to one. Moreover, in most of the researches, the choice of input variables suffers from omission of important inputs such as local seed, improved seed, compost, herbicides and insecticides. Moreover, the technical efficiency determinants used in the models are limited in number especially in the models of Zenebe and Yesuf (2013), and Gebrehawaria *et al*. (2012). Therefore, this research can solve some of these limitations of the preceding researches by carefully incorporating the possible input and exogenous variables for each crop type.

3. Research Methodology

3.1 Method of Data Collection and Sampling Techniques

This study used a primary data collected from farm households of the Central Zone of Tigray in the 2014 cropping season. In the outset, the author prepared a structured questionnaire and the data is collected using interview method. The interview method is chosen in view of expecting significant number of illiterate farm households.

According to CSA (2007) data, the Central Zone contains 10 Woredas, 187 Kebeles/Tabias and 225,343 farm households. Each Tabia contains smaller residential places called *Kushets*. The author has employed a combination of non-probability and probability sampling techniques under a general multi stage sampling framework. Initially, 3 Woredas namely ***Kola-Temben, Werie-Lekhe and Lailai-Maichew*** are selected using purposive sampling in terms of their population size and main crops cultivated. This technique is chosen to address the problems of majority of the population in the production of their main crops. Next, 3 Tabias from Werie-Lekhe [*Maychekente, Maekelawi, and Endachewa*], and 2 Tabias each from Kola-Temben [*Begashekha and Dr. Atakilti*] and Lailai-Maichew [*Dura and Hatsebo*] woredas are selected randomly. Then, 2 Kushets from each Tabia are selected using simple random sampling technique. Finally, the sample farm households are taken from the sampled Kushets. Initially, the author has selected a total of 500 sample farm households. From these sampled households, 10 respondents have refused to participate in the interview and 490 samples are used in this study. The samples were equally distributed among the sampled “Tabias”.

3.2 Method of Data Analysis

Analysis of the data is made using both descriptive and econometric tools of data analysis. Under descriptive method, the author used simple statistical measures such as percentages and means. Besides, the author used tabular and graphical presentations of these statistical tools. Under the econometric analysis, the author employed a single step stochastic frontier model to estimate the level of technical efficiency of farmers and the determinants of technical efficiency. The stochastic frontier model is estimated using STATA software version 11.

3.3 Analytical Framework

Aigner, Lovell and Schmidt (1977); and Meeusen and Van den Broeck (1977) have developed a stochastic frontier production function for the purpose of estimating the level of technical efficiency of firms in production. The stochastic frontier production function can be given by;

$$Y_i = f(X_i, \beta) + \varepsilon_i \qquad (1)$$

Where, Y is output, f (.) is the production technology, X represents vector of inputs, and β is vector of parameters to be estimated. Moreover; ε is the error term of the model consisting of two components v and u such that;

$$\varepsilon_i = v_i - u_i;\ u_i \geq 0 \qquad (2)$$

Where v_i is a symmetric error term that captures deviations of actual production from the frontier because of favourable or unfavourable factors beyond the control of the producers such as drought, weather, luck, measurement error, etc. It is independently and identically distributed as $N(0, \sigma^2_v)$. The frontier production function is said to be stochastic because of this error term and producers can produce beyond the frontier when the value of v_i is positive and large. On the other hand, u_i shows the inefficiency of farmers from factors under their control such as technical and economic inefficiency, the will and effort of the farmers, and possibility of defective and damaged products. The error term u_i is assumed to be independent of vi and assumed to have half normal distribution of the form $N^+(0.\sigma^2_u)$.

Following Battese and Coelli (1995), the model can be estimated using maximum likelihood technique and one can find consistent estimators of $\beta.\sigma.$ and λ such that $\sigma^2 = \sigma_u{}^2 + \sigma_v{}^2$ and $\lambda = \sigma_u / \sigma_v$. Moreover, the technical efficiency level of firms can be given by;

$$TE_i = \frac{Y_i}{f(X_i.\beta)exp\{v_i\}} = \frac{f(X_i.\beta)exp\{\varepsilon_i\}}{f(X_i.\beta)exp\{v_i\}} = \frac{f(X_i.\beta)exp\{v_i - u_i\}}{f(X_i.\beta)exp\{v_i\}} = exp\{-u_i\} \qquad (3)$$

From Equation 3, technical efficiency is given as a ratio of the observed output to the maximum feasible (frontier) output level. However, it is the ε_i not the u_i and v_i observed in Equation 3. Therefore, the technical efficiency of firms can be estimated using the expectation of u_i conditional on ε_i after Jondrow *et al.*, (1982). Then, we can have;

$$TE_i = \exp(-\hat{u}_i) = expE\left\{\frac{-u_i}{\varepsilon_i}\right\} \qquad \textbf{(4)}$$

Where the estimator of u_i is given by:

$$\hat{u}_i = E\left(\frac{u}{\varepsilon}\right) = \left[\frac{\sigma\lambda}{1+\lambda^2}\right]\left[z_i + \frac{\phi(z_i)}{\Phi(z_i)}\right] \qquad \textbf{(5)}$$

Where $z_i = \frac{-\varepsilon_i\lambda}{\sigma}$ and $\lambda = \sigma_u/\sigma_v$, ϕ (.) is the standard normal density function and Φ (.) is the distribution function. The existence of technical inefficiency can be tested by the parameter λ such that the null hypothesis $\lambda = 0$ is tested against the alternative hypothesis $\lambda > 0$. The level of technical efficiency lies between 0 and 1.

The Model

For the purpose of estimating individual farmer's level of efficiency in cereal production, the researcher has employed the Cobb-Douglas type of stochastic frontier production function. There are two ways of estimating stochastic frontier models; the two step procedure and the direct or single step procedure. In the two step procedure, the Cobb-Douglas production function relating farm inputs to output is estimated at first and the level of technical efficiency is predicted from this model. In the second step, the predicted technical efficiency is regressed on the variables affecting technical efficiency. In the single step method, both the farm inputs and the variables affecting technical efficiency are incorporated in the production function and a single model is estimated.

According to Kumbhakar and Lovell (2000), the two step procedure has a problem with respect to failure in assumptions. The level of technical efficiency of farmers is predicted from the half normally distributed term, u_i, with zero mean value and a constant variance of$\pm_{u}^{2}$. A variable with zero mean value can, therefore, not be regressed on other variables otherwise, it yields biased and inconsistent estimates. Moreover, unless the Z variables and the X variables are true orthogonal, the two step procedure yields biased and inconsistent estimates. The solution for this problem is to use the single step approach. Therefore, the author has also chosen the single step approach in this study as well. The stochastic frontier model, in this case, is given by:

$$lnY_{ji} = lnf\left(X_{ji}, Z_{jq}; \beta\right) + v_{ji} - u_{ji} \qquad (6)$$

Where j=1, 2, 3 represents the frontier production function for *Teff*, Maize and Sorghum farmers respectively. Therefore, $\boldsymbol{Y_{1i}}$ represents *Teff* production, $\mathbf{Y_{2i}}$ represents Maize production and $\mathbf{Y_{3i}}$ represents Sorghum production. Moreover, $\mathbf{X_{ji}}$ are the input variables, $\mathbf{Z_{jq}}$ are the exogenous variables affecting technical efficiency, $\boldsymbol{\beta}$ are the parameters, $\mathbf{v_{ji}}$ is the symmetric error term and $\mathbf{u_{ji}}$ is the half normal error term capturing the discrepancy of actual output from potential output due to inefficiency.

Description of Variables

Table 1: Description of variables used in the model

Category	Variable Name	Description
Dependent	Output	Output in quintals
X-Variables or Farm Inputs	Oxen days	
	Man days	
	Compost	Compost in quintal
	Fertilizer	Dap+Urea in quintal
	Improved seed	In quintal
	Local seed	In quintal
	Land	In hectare
	Insecticide	Insecticide in liters
	Herbicide	Herbicide in liters
Z-Variables or Efficiency Variables	Sex	1 if household head is male 0 if female
	Age	Age of household head
	Age2	
	Education	Years of schooling of the household head
	Main crop	1 if main crop 0 otherwise
	Market distance	Distance to nearest market place in minutes
	Irrigation	1 if yes and 0 if no irrigation
	Training[2]	1 if took training on modern input use and 0 otherwise
	Suboptimal adoption[3]	1 if farmers use lower or higher amount of fertilizer than the standard amount of fertilizer required and 0 otherwise
	Land distance	Distance of farm land from home in minutes
	Credit	1 if took credit and 0 otherwise
	Off-farm income	Off-farm income in Birr
	DKolatemben	1 if a farmer lives in Kola-Temben and 0 otherwise
	DWerielekhe	1 if a farmer lives in Werie-Lekhe and 0 otherwise

[2]Most of the farmers are beneficiaries of extension services. Therefore, training on modern input use is used as a policy variable to determine efficiency instead of extension service.

[3]Farmers who use fertilizers less than or greater than the standard are considered as suboptimal adopters and most of the farmer respondents in this study have used lower amount of fertilizer than the standard amount of fertilizer required. The standard amount of fertilizer required is 50 kg per 0.25 hectares of land.

4. Discussion and Data Analysis

4.1 Descriptive Analysis

From the total of 490 respondents, 219 (44.7%) are from Werie-Lekhe, 148 (30.2%) are from Kola-Temben, and the rest 123(25%) are from Lailai-Maichew Woreda.

Table 2: Background of the respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
Sex	490	0.78	.4135603	0	1
Age	490	47	10.7359	24	82
Education	490	3.25	3.164734	0	13
Household Size	490	5.8	2.001711	1	10
Livestock Wealth	490	22596.34	12555.37	0	119300
Off-farm Income	490	3506.962	4891.08	0	50000
Distance to main market	490	89.24898	43.66281	5	225

Source: own survey data, 2015.

From Table 2, 78% of the respondents are male headed and the rest 22% are female headed farm households. The average age, year of schooling, and household size of the respondents is 47 years, 3.25 years, and 5.8 respectively. This indicates how much uneducated the farm households are in the study area. Moreover, the average livestock wealth and average off-farm income of the households in 2015 are found to be 22596 Birr and 3507 Birr respectively. The average distance from the respondents’ home to the main market place is 89 minutes, i.e, the farmers have to travel for about 1 hour and 30 minutes to reach the nearest main market place on average.

Table 3: Characteristics of respondents by main crop, irrigation, technology adoption and credit

Variables	Obsn	Frequency	Percent
Teff Main Crop	490	230	47
Maize Main Crop	490	134	27.3
Sorghum Main Crop	490	126	25.7
Irrigation Users	490	120	25
Agriculture Extension	490	479	98.3
Training on Modern Input Use	490	422	86
Suboptimal Adoption	490	215	43.9
Credit Access	490	320	65.4

Source: own survey data, 2015

As we can see from Table 3, majority of the respondents are producers of *Teff* as main crop (47%) followed by Maize (27.3%) and Sorghum (25.7%). Moreover, 25% of the respondents have access for irrigation, 98.3% and 86% of the respondents are beneficiaries of agricultural extension services and have taken training on modern input use. Finally, 44% of the respondents have used suboptimal fertilizer (lower or higher fertilizer than the standard required) and 65.4% of the farmers have taken credit from microfinance.

Table 4: Mean values of the output and input variables by crop type

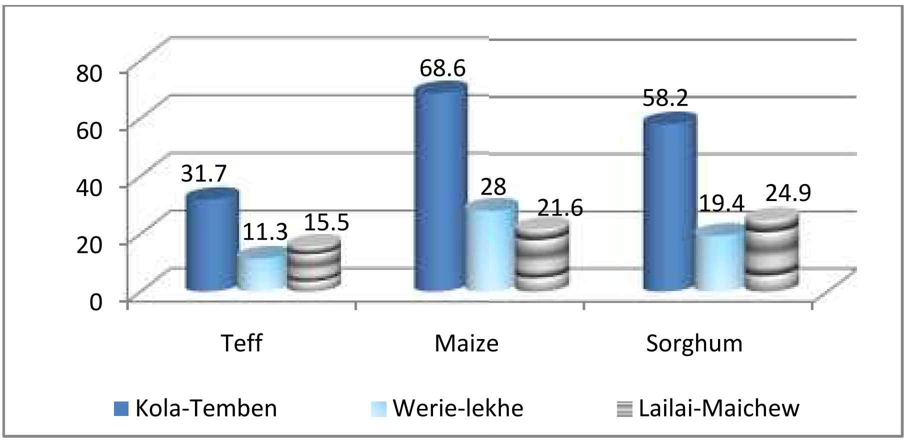
Variables	***Teff*** **Mean Values: N=457**	**Maize Mean Values: N=291**	**Sorghum Mean Values: N=268**
Output (in qt)	6.41	9.60	8.60
Yield (qt/ha)	17.73	46.70	34.40
Land (ha)	0.45	0.24	0.32
Land Distance (minutes)	26.30	5.27	17.45
Local Seed (qt)	0.15	0.06	0.14
Improved Seed (qt)	0.06	0.058	0.02
Fertilizer (qt)	0.58	0.32	0.27
Compost (qt)	3.93	8.59	4.81
Herbicide (liters)	0.18	0.002	0.013
Insecticide (liters)	0.22	0.114	0.07
Man Days	18.68	13.47	14.41
Oxen Days	5.38	3.02	3.68

Source: Own survey data, 2015

As we can see from Table 4, Maize yields are found to be higher than that of Sorghum and *Teff*. The average yields of *Teff*, Maize and Sorghum are 17.73 qt/ha, 46.70 qt/ha, and 34.40 qt/ha respectively. The average yields in all crops of the Central Zone of Tigray region have been increased as compared to the 20113/14 CSA reports of 13.4 qt/ha, 19.5 qt/ha, and 17.2 qt/ha for *Teff*, Maize, and Sorghum respectively. *Teff* farms are found far from the farmers' homes whereas Mize farms are nearest to the farmers' homes. On average, the farmers have to travel 26.5, and 17 minutes from their home to the *Teff*, Maize, and Sorghum farms respectively. Moreover, farmers tend to use more quintals of seeds, fertilizer, land, man days, oxen days, herbicides, and insecticides in *Teff* production as compared to the other two crops. However, they tend to use more compost in maize production than any other crop.

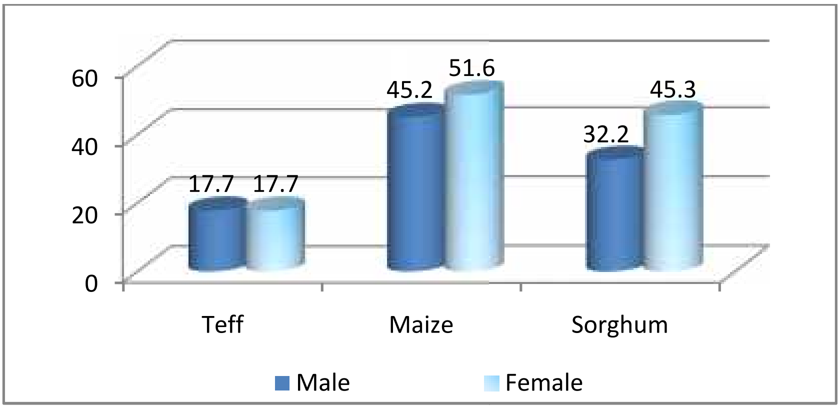
There is considerable difference in crop yield across the three sampled Woredas and across sex of household heads. Crop yield across Woredas and sex of household heads are given in the following successive figures respectively.

Figure 1: Average crop yield by Woreda



From Figure 1, Kola-Temben Woreda is found to have the highest yield in all crops with yields of 31.7 qt/ha, 68.6 qt/ha, and 58 qt/ha in *Teff*, Maize, and Sorghum respectively. Lilai-Maichew Woreda has the second highest yield in *Teff* and Sorghum with 15.5 qt/ha and 24.9 qt/ha respectively and the least yield of 21.6 qt/ha in Maize production. On the other hand, Werie-Lekhe has the second highest yield of 28 qt/ha in Maize and the least yields in *Teff* and Sorghum production with 11.3 qt/ha and 19.4 qt/ha respectively.

Figure 2: Average crop yield by Sex



From Figure 2, female headed households are found to have higher yields in Maize and Sorghum production with yields of 51.6 qt/ha and 45.3 qt/ha respectively than their male counterparts with yields of 45.2 qt/ha and 32.2 qt/ha respectively. On the other hand, female headed and male headed households have similar yield in *Teff* production of 17.7 qt/ha.

4.2 Model Estimation

A single step stochastic frontier mode is estimated to examine whether the farmers are technically efficient or not. Before estimation, pairwise correlation coefficients of the variables are examined. Based on the correlation coefficients, Oxen Days and Land are found to have high correlation in all crop types. The correlation between these two variables is found to be 0.947. 0.933. and 0.887 in *Teff*, Maize and Sorghum production respectively. This high correlation has significantly disturbed the regression outputs of for all crops in terms of magnitude and sign. Thus, the variable

Land is dropped from the models. The pair wise correlations of variables incorporated in the models are given in Appendix 1.

Table 4: Regression output of the stochastic frontier model by crop type

Crop Type	***Teff*: N=457**	**Maize: N=291**	**Sorghum: N=268**
X-Variables (Inputs)	**Coefficient**	**Coefficient**	**Coefficient**
Oxendays	0.2755649***	0.3024668***	0.3640958***
Mandays	0.1848228**	0.2149374***	0.2583911***
Compost	0.0079744	0.0221437**	0.0299424***
Fertilizer	0.133586***	0.0620407*	0.0662829**
Improvedseed	0.0952313***	0.0421137	0.1391927***
Localseed	0.0951763***	0.1854429***	0.2023589***
Insecticide	0.0606021***	0.0309678*	0.0554487**
Herbicide	0.0840701***	0.0798451	-0.0875173*
Z-Variables [Efficiency Determinants]			
Sex	0.0813734	0.0501357	-0.0302528
Age	0.0016136	0.2901372	0.5028591***
Age2	(omitted)	(omitted)	(omitted)
Education	-0.014189	0.0163711*	0.0170808
Maincrop	0.1706371***	0.4262037***	0.1945057**
Distance to market	0.0275611	-0.1257748*	0.0004059
Irrigation	0.1277673*	0.1504732**	-0.0582976
Training	0.2241505***	0.3787265***	0.0143335
Suboptimal adoption	0.0745929	-0.0946952*	0.08549
Land distance	-0.0479504	0.1312072***	-0.0387757
Credit	0.2349411***	0.0612902	0.1151666*
Off-farmincome	-0.0101675**	-0.0109974**	-0.0126212**
DKola-Temben	0.3581391***	0.7908351***	0.4514125***
DWerie-Lekhe	-0.1500244**	0.114353	-0.4432852***
_cons	1.778571***	0.7659075	0.176119
/lnsig2v	-2.670632***	-1.89396***	-1.957292***
/lnsig2u	-0.6915435***	-10.17787***	-2.12298
sigma_v	0.2630751	0.3879107	0.3758195
sigma_u	0.707674	0.0061646	0.3459399
sigma2	0.570011	0.1505127	0.2609147
lambda	2.690008***	0.0158917***	0.9204947

Source: Own estimation, 2015

***, **, and * indicate significant variables at α=1%. α=5% and α=10% respectively

In the stochastic frontier model, we have two sets of variables; the X-variables or the farm inputs and the exogenous Z-variables or the determinants of technical efficiency. Interpretation of the Z-variables can be viewed in terms of their effect on the production function and on the technical efficiency of the farmers. i.e On the one hand, they can shift the production function either outwards or inwards; on the other hand, they can affect the technical efficiency of the farmers either positively or negatively. However, the magnitude of the effect on technical efficiency is not directly known from the regression outputs.

From the regression Table 4, the variance of the half normal term, $\pm_u^2$, and the technical inefficiency parameter, Lambda, are found to be significant in *Teff* and Maize production. This shows the existence of technical inefficiency of farmers in the production of these two crops. However, the predicted level of technical efficiency of farmers in *Teff* production, as shown in Figure 3, is found to be 99.2% and thus the technical inefficiency of farmers is infinitesimal. Moreover, the technical inefficiency parameter, Lambda, is found to be insignificant and thus farmers are found to be technically efficient in Sorghum production. This indicates that the deviation of actual output from frontier output in *Teff* and Sorghum production is dominated by stochastic factors such as drought, bad weather condition and others beyond the farmers' control. The reason behind the low level of output in *Teff* and Maize production is, therefore, the low level of current technology available to the farmers. This implies that increasing *Teff* and Sorghum output requires shifting the current technology rather than urging farmers to change their practices. Finally, the average level of technical efficiency of Maize producers is found to be 95.5% which indicates a room for about 4.5% efficiency gains.

From the group of the input variables, Oxen days, Man days, Fertilizer, Improved seed, Local seed, Insecticide and Herbicide are found to have positive and significant effect on *Teff* output. Similarly, Oxen days, Man days, Compost, Fertilizer (at 10%), Local seed and Insecticide (at 10%) are found to have positive and significant effect on Maize output. However, improved seed and herbicide in Maize production and Compost in *Teff* production are found to be insignificant. In Sorghum production, herbicide (at 10%) is found to have negative and significant effect and the rest input variables are found to have positive and significant effect on output. Therefore, Sorghum farmers better to weed-out the herbs than trying to kill those using chemicals. In most of the preceding studies, Man Days is found to have insignificant effect on output. The highly significant Man Days in this study indicates that the agricultural sector is not subjected to excess labor with zero marginal productivity in the study area. This might be attributed to rural-urban migration of the rural youth for education and job search which leaves the agricultural sector with less availability of labor.

From the group of exogenous variables affecting efficiency, the dummies for Main crop, Irrigation (at 10%), Training, and credit are found to be positive and significant in *Teff* production. Besides, the dummy for Kola-Temben is positive and significant whereas the dummy for Werie-Lekhe is found to be negative and significant. This implies that *Teff* output in Kola-Temben is higher than Lailai-Maichewand *Teff* output in Werie-Lekhe is lower than Lailai-Maichew. On the other hand, Off-farm income is found to have negative and significant effect on *Teff* output. The higher the farmers get income from off-farm activities, the lesser the quantity of *Teff* output they produce. The remaining determinants such as Sex, Age, Education, Distance to market, Land distance and suboptimal adoption are found to be insignificant in *Teff* production. By suboptimal adoption, we mean the use of chemical fertilizers lower than or higher than from the standard amount required. Therefore, *Teff* output is not affected whether the farmers use the standard amount of fertilizer or not.

In Maize production, Education, the dummy for Main crop, Irrigation, Training, Land distance and the dummy for Kola-Temben are found to be positive and significant. However, Distance to market (at 10%), suboptimal adoption (at 10%). and Off-farm income are found to be negative and significant. The remaining variables Sex, Age, Credit and the dummy for Werie-Lekhe are found to be insignificant. Therefore, longer market distance and higher off-farm income reduces technical efficiency of farmers in Maize production. Suboptimal technology adoption or using fertilizers below or above the standard is also likely to reduce technical efficiency of farmers. Moreover, technical efficiency of farmers in Kola-Temben is found to be higher than that of farmers in Lailai-Maichew. But, there is no significant difference in technical efficiency of farmers in Lailai-Maichew and Werie-Lekhe. On the other hand, the positive and unexpected effect of land distance on Maize output might be due to the fact that maize cultivated near the farmer’s home is eaten during spiking and before harvesting.

In Sorghum production, the exogenous variables Age, Main crop, Credit (at 10%), and the dummy for Kola-Temben are found to be positive and significant whereas Off-farm income and the dummy for Werie-Lekhe are found to be negative and significant. Once more, farmers in Kola-Temben produce higher output than Lailai-Maichew and farmers in Werie-Lekhe produce lower output than Lailai-Maichew. The exogenous variables Sex, Education, Distance to market, Irrigation, Training, suboptimal adoption and Land distance are found to have insignificant effect on Sorghum output.

Finally, the estimated coefficients are elasticities and their interpretation can be made in terms of percentage changes. For instance, the coefficient of oxen days in *Teff* production can be interpreted as “1% increase in oxen days leads to a 0.27% rise in *Teff* output”. Similarly, the coefficients of the dummy variables show a percentage difference in output between the categories. For instance, the coefficient of the dummy for Training in *Teff* production can be interpreted as “Output of farmers who took training is higher than output of farmers who didn’t take training by 0.22% in *Teff* production”. The coefficients of other variables can be interpreted in a similar way.

As we have seen in the regression output, farmers are found to be technically inefficient in the production of *Teff* and Maize though the predicted average level of technical inefficiency in *Teff* production is infinitesimal. The levels of technical efficiency of farmers in *Teff* and Maize production are summarized in the following table.

Table 5: Levels of technical efficiency of farmers in *Teff* and Maize production

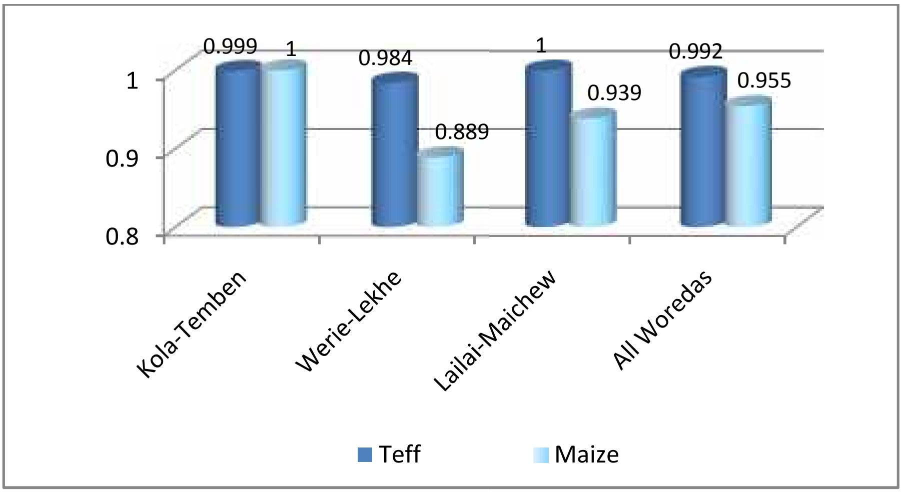
Efficiency Levels	*Teff*		Maize	
	Frequency	Percent	Frequency	Percent
[0.000-0.100)	1	0.22	0	0
[0.100-0.200)	0	0	0	0
[0.200-0.300)	0	0	2	0.7
[0.300-0.400)	0	0	3	1.03
[0.400-0.500)	0	0	4	1.37
[0.500-0.600)	0	0	5	1.72
[0.600-0.700)	1	0.22	7	2.4
[0.700-0.800)	4	0.87	6	2.06
[0.800-0.900)	5	1.1	5	1.72
[0.900-1.000)	7	1.53	7	2.4
1	439	96.06	252	86.6
Total	**457**	**100**	**291**	**100**

Source: Own computation, 2015.

As we can see from Table 5, only 18(4%) *Teff* producing farmers are found to be technically inefficient and the remaining 439 (96%) farmers are found to be efficient. Moreover, except one farmer whose level of efficiency is in the range [0.000-0.100), the level of efficiency of majority of the inefficient farmers is above 0.600. Moreover, 39 (13.4%) Maize producers are found to be technically inefficient and the rest 252 (86.6%) farmers are found to be efficient. Majority of the inefficient farmers have efficiency levels of above 0.6000 in Maize production as well. As we can see from Figure 3 below, the predicted level of technical efficiency in *Teff* and Maize production are found to be 99.2% and 95.5% respectively. The technical inefficiency of farmers in *Teff* is negligible while there is about 4.5% room for improvement from efficiency in Maize production.

There is no evidence of technical inefficiency in Sorghum. negligible inefficiency in *Teff* and only 4.5% inefficiency in Maize production in contrast to the findings of the preceding studies made by Shumet (2012), Zenebe and Yesuf (2013), and Endrias *et al.,* (2012). This might be attributed to the differences in the choice of the input variables, the exogenous variables, sample sizes, and model specifications between this study and the preceding ones. Moreover, efficiency of farmers over the last couple of years might have improved with all the trainings and extension services provided to the farmers.

Figure 3: Average technical efficiency of *Teff* and Maize production by Woreda



The technical efficiency of farmers in *Teff* and Maize production also differs across the sampled Woredas. As we can see from Figure 3, all farmers in Kola-Temben are found to be technically efficient in both *Teff* and Maize. Farmers in Lailai-Maichew are technically efficient in *Teff* but not in Maize production. Farmers in Lailai-Maichew have a possibility of about 6% room for improvement in Maize production. Finally, farmers in Werie-Lekhe are found to be the least technically efficient producers in both *Teff* and Maize production with a possibility of 1.6% and 11% room for improvement respectively.

5. Conclusions and Recommendations

5.1 Conclusions

As per the preceding empirical evidences and annual reports of the government, Tigray region is reported to have low level of crop productivity and farmers technical efficiency. On the other hand, the region is reported to be one of the poorest regions in terms of food poverty and total poverty in Ethiopia. Having this in mind, the author is motivated to carry out this study with the objective of examining the technical efficiency of farmers in the production of *Teff*, Maize, and Sorghum which are the major cereals produced in the central zone of Tigray. To this end, the author has collected a primary data from the farm households in the 2014 cropping season and found encouraging results. This study differs from the preceding ones in three ways. First, it is more comprehensive in terms of the choice of the input variables and the exogenous variables affecting the technical efficiency of farmers. Secondly, unlike the preceding similar studies, a stochastic frontier model is estimated for the production of *Teff*, Maize and Sorghum separately rather than using market value of the cereals and estimating a single stochastic frontier model for the aggregated output. Thirdly, the sample size is more representative in view of the geographical scope and the size of respondents used in the study.

Based on the stochastic frontier regression output, there is evidence of technical inefficiency in *Teff* and Maize but not in Sorghum production. However, the predicted level of technical inefficiency in *Teff* production is infinitesimal. The deviation of actual output from frontier output in *Teff* and Sorghum production is, therefore, said to be dominated by factors beyond the control of the farmers. In other words, *Teff* and Sorghum producers are technically efficient under the current technology and increasing output is possible through shifting the current level of technology rather than urging farmers to change their activities. Only Maize producing farmers are found to be technically inefficient with a possibility of 4.5% efficiency gains.

As far as the input variables are concerned, all of them except compost in *Teff*, Improved seed and Herbicide in Maize and Herbicide in Sorghum, are found to be significant and with the expected positive sign. Compost is not significant in *Teff*. Improved seed and Herbicides are not significant in Maize and herbicide is negative and significant in Sorghum production. The most important finding in this study is the significant effect of Mandays or labor on output of all crops. This indicates that the farms are not characterized by excess labor with zero or negative marginal productivity in the study area in contrast to the findings of the preceding studies where labor was found to be insignificant.

When we come to the exogenous variables, the dummy for Main crop positively affects output while Off-farm income negatively affects output of all crops. Moreover, Irrigation and Training positively affect *Teff* and Maize whereas Credit positively affects *Teff* and Sorghum output. Suboptimal technology adoption is insignificant in *Teff* and Sorghum and negative and significant in Maize production. In other words, *Teff* and Sorghum output are not affected whether farmers use fertilizers according to the standard set or not. Interestingly, there is no significant difference in output between male headed and female headed households across the three crop types. Finally, farmers in Kola-Temben produce significantly higher output in all crops followed by farmers in Lailai-Maichew and Werie-Lekhe.

5.2 Recommendations

Based on the empirical findings presented above, the author has the following recommendations to the farmers in the Zone and the concerned policy makers at Regional or Zonal levels.

- Except the low level of technical inefficiency in Maize production, farmers are found to be efficient producers. Any deviation of actual output from the potential (frontier) output is dominated by random factors such as drought, flooding, bad weather and other shocks which are beyond their control. Moreover, the low level of output is attributed to the backward technology with which the farmers are producing. Therefore, the government and other concerned bodies should emphasize in introducing new production technology to push the current production frontier outwards and increase output.

- Farmers who took training on modern input use are found to have significantly higher output in *Teff* and Mize production. Therefore, the government should give further training on modern input use to the farmers who didn't take training.
- Compulsory technology adoption doesn't affect output in *Teff* and Sorghum production. This implies that farmers have the knowledge about their land characteristics and the weather condition which helps them fix the amount of fertilizer to use. Therefore, it might not be fruitful urging the farmers to use the standard amount of fertilizer unless the standard is set based on the agro-ecological characteristics of their farm land.
- The government and other concerned bodies should create conducive environment on credit access for the farmers. Purchase of modern inputs such as fertilizers and improved seeds require higher outlay which might be difficult for the farmers to afford. These costs can be covered through credit only.
- The government and other concerned bodies should expand irrigation access for the farmers. Irrigation increases output because it helps the farmers produce more than once a year and creates sustainable water source for their crops.
- Farmers in Werie-Lekhe Woreda need special attention in terms of their technical inefficiency and lower productivity as compared to those in Lailai-Miachew and Kola-Temben in the production of the three crops.
- Herbicides tend to increase output in Maize and *Teff* production while they tend to reduce output in Sorghum production. Therefore, Sorghum farmers have to weed-out the herbs rather than using chemicals to avoid them.
- Farmers should not be reluctant in using the standard amount of fertilizers in Maize production for economic reasons such as higher

prices. Because, using fertilizer less than the standard amount tends to reduce output.

- Farmers producing as a main crop have higher output as compared to the farmers producing as a subbed crop. This calls for the superiority of specialization in crop production over diversification to increase their output and efficiency.
- Off-farm activities negatively affect output in all crops. Therefore, farmers should pay full attention to farming especially during the rainy season. Off-farm activities should be done whenever the farmers are free from farming activities.

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Appendix
Appendix 1: Pairwise Correlation of Variables

A) *Teff*

pwcorr Totallandteff Oxendaysteff Mandaysteff Insecticideteff Herbicideteff Compostteff Fertilizer Improvedseed Localseed Landistanceteff Distancemarket Offarmincome

Variables	Land	Oxen days	Man days	Insecticide	Herbicide	Compost	Fertilizer	Improved seed	Local seed	Land distance	Distance market	Off-farm income
Land	1											
Oxen days	**0.9473**	1										
Man days	0.6791	0.6734	1									
Insecticide	0.3349	0.3618	0.0925	1								
Herbicide	0.2149	0.2294	0.0298	0.4896	1							
Compost	0.2612	0.2615	0.0653	-0.0081	-0.0777	1						
Fertilizer	0.5736	0.5901	0.3641	0.3539	0.1881	0.2373	1					
Improved seed	0.2915	0.285	0.1062	0.1279	0.1174	0.184	0.2603	1				
Local seed	0.5773	0.5552	0.5179	0.1394	0.14	0.1955	0.239	0.1467	1			
Land distance	0.056	0.0546	0.0299	0.1966	0.244	-0.129	0.0112	-0.03	0.0588	1		
Distance market	-0.1345	-0.0935	-0.009	0.1686	0.2592	-0.2155	-0.0472	0.0346	0.0037	0.2146	1	
Off-farm income	-0.1968	-0.1544	-0.0803	0.0571	0.1776	-0.2323	-0.1269	-0.0222	-0.0711	0.0684	0.3508	1

B) Maize

pwcorr Totallandmaize Oxendaysmaize Mandaysmaize Insecticidemaize Herbicidemaize Compostmaize Fert imp loc Landistancemaize Distancemarket Offarmincome

Variables	Land	Oxen days	Man days	Insecticide	Herbicide	Compost	Fertilizer	Improved seed	Local seed	Land distance	Distance market	Off-farm income
Land	1											
Oxen days	**0.9335**	1										
Man days	0.4675	0.5031	1									
Insecticide	0.2019	0.1864	-0.0643	1								
Herbicide	0.2086	0.2038	0.0695	-0.0055	1							
Compost	0.2616	0.2141	0.0743	0.5404	0.0166	1						
Fertilizer	0.361	0.3848	0.5961	-0.0749	0.1313	0.0498	1					
Improved seed	0.4463	0.4545	0.5717	0.164	0.0575	0.1954	0.6098	1				
Local seed	0.3254	0.3119	0	0.3726	0.1482	0.4169	-0.1003	-0.1892	1			
Land distance	0.1485	0.1512	-0.0845	0.0013	0.0436	0.0905	-0.0185	-0.0935	0.1486	1		
Distance market	0.3206	0.301	0.413	0.1845	0.0864	0.352	0.2708	0.3492	0.2385	-0.0517	1	
Off-farm income	0.2345	0.2799	0.2873	0.1762	0.195	0.2738	0.2952	0.365	0.1271	-0.1729	0.3508	1

C) Sorghum

pwcorr Totallandsorghum Oxendayssorghum Mandayssorghum Insecticidesorghum Herbicidesorghum Compostsorghum Fertilizer Improvedseed Localseed Landistancesorghum Distancemarket Offarmincome

Variables	Land	Oxen days	Man days	Insecticide	Herbicide	Compost	Fertilizer	Improved seed	Local seed	Land distance	Distance market	Off-farm income
Land	1											
Oxen days	**0.8877**	1										
Man days	0.5115	0.5024	1									
Insecticide	-0.0707	-0.0466	0.0766	1								
Herbicide	-0.0593	-0.0547	0.0034	-0.0474	1							
Compost	-0.068	-0.0588	-0.0059	0.1503	0.0462	1						
Fertilizer	0.0789	0.1353	0.0545	0.1241	-0.0106	0.2798	1					
Improved seed	-0.0361	-0.0719	0.0241	0.0007	0.2727	0.1162	0.0753	1				
Local seed	0.382	0.3745	0.3159	0.0498	-0.1304	0.0714	0.209	-0.1912	1			
Land distance	0.1369	0.1194	-0.0709	-0.3268	-0.0279	-0.1257	-0.0031	0.014	0.138	1		
Distance market	-0.0903	0.0817	0.1462	-0.1491	0.0882	-0.2717	-0.2695	0.2219	0.0488	0.2476	1	
Off-farm income	-0.1559	-0.0369	0.0579	0.0283	0.0825	-0.1607	-0.0956	0.2109	-0.0438	0.1417	0.3508	1

Appendix 2: Regression Outputs

A) *Teff*

frontier LNOutput LNOxendays LNMandays LNCompost LNFertilizer LNImprovedseed LNLocalseed LNInsecticide LNHerbicide Sex LNAge LNAge2 LNEducation Maincrop LNDistancemarket Irrigation Training Compulsoryadoption LNLandistance Credit LNOffarmincome DKolatemben DWerielekhe. vce(robust)

note: LNAge2 omitted because of collinearity

Iteration 0: log pseudolikelihood = -321.56194

Iteration 1: log pseudolikelihood = -317.48356

Iteration 2: log pseudolikelihood = -317.26084

Iteration 3: log pseudolikelihood = -317.26031

Iteration 4: log pseudolikelihood = -317.26031

Stoc. frontier normal/half-normal model Number of obs = 457

Wald chi2(21) = 1282.83

Log pseudolikelihood = -317.26031 Prob > chi2 = 0.0000

Robust						
LNOutput	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**	**Interval]**
LNOxendays	0.2755649	0.0712645	3.87	0	0.135889	0.415241
LNMandays	0.1848228	0.0755695	2.45	0.014	0.036709	0.332936
LNCompost	0.0079744	0.0089902	0.89	0.375	-0.009646	0.025595
LNFertilizer	0.133586	0.0334867	3.99	0	0.067953	0.199219
LNImprovedseed	0.0952313	0.020143	4.73	0	0.055752	0.134711
LNLocalseed	0.0951763	0.0330981	2.88	0.004	0.030305	0.160047
LNInsecticide	0.0606021	0.015996	3.79	0	0.029251	0.091954
LNHerbicide	0.0840701	0.0162193	5.18	0	0.052281	0.115859
Sex	0.0813734	0.053785	1.51	0.13	-0.024043	0.18679
LNAge	0.0016136	0.1319018	0.01	0.99	-0.256909	0.260136
LNAge2	(omitted)					
LNEducation	-0.014189	0.0093106	-1.52	0.128	-0.032437	0.004059
Maincrop	0.1706371	0.0537577	3.17	0.002	0.065274	0.276
LNDistancemarket	0.0275611	0.043408	0.63	0.525	-0.057517	0.112639
Irrigation	0.1277673	0.0720853	1.77	0.076	-0.013517	0.269052
Training	0.2241505	0.0746064	3	0.003	0.077925	0.370376
Compulsoryadoption	0.0745929	0.0510048	1.46	0.144	-0.025375	0.174561
LNLandistance	-0.0479504	0.0349318	-1.37	0.17	-0.116416	0.020515
Credit	0.2349411	0.0472117	4.98	0	0.142408	0.327474
LNOffarmincome	-0.0101675	0.0041663	-2.44	0.015	-0.018333	-0.002
DKolatemben	0.3581391	0.1114513	3.21	0.001	0.139699	0.57658
DWerielekhe	-0.1500244	0.0725417	-2.07	0.039	-0.292204	-0.00785
_cons	1.778571	0.5846233	3.04	0.002	0.63273	2.924412
/lnsig2v	-2.670632	0.331558	-8.05	0	-3.320473	-2.02079
/lnsig2u	-0.6915435	0.1824869	-3.79	0	-1.049211	-0.33388
sigma_v	0.2630751	0.0436123			0.190094	0.364075
sigma_u	0.707674	0.0645706			0.591789	0.846252
sigma2	0.570011	0.0738484			0.425271	0.714751
lambda	2.690008	0.1032994			2.487545	2.892471

B) Maize

frontier LNOutput LNOxendays LNMandays LNCompost LNFertilizer LNImprovedseed LNLocalseed LNInsecticide LNHerbicide Sex LNAge LNAge2 LNEducation Maincrop LNDistancemarket Irrigation Training Compulsoryadoption LNLandistance Credit LNOffarmincome DKolatemben DWerielekhe. vce(robust)

note: LNAge2 omitted because of collinearity

Iteration 0: log pseudolikelihood = -137.37981
Iteration 1: log pseudolikelihood = -137.37764
Iteration 2: log pseudolikelihood = -137.36039
Iteration 3: log pseudolikelihood = -137.35923
Iteration 4: log pseudolikelihood = -137.35521
Iteration 5: log pseudolikelihood = -137.35505
Iteration 6: log pseudolikelihood = -137.35378
Iteration 7: log pseudolikelihood = -137.35353
Iteration 8: log pseudolikelihood = -137.35331
Iteration 9: log pseudolikelihood = -137.35321
Iteration 10: log pseudolikelihood = -137.35313

Iteration 11: log pseudolikelihood = -137.35313
Iteration 12: log pseudolikelihood = -137.35311
Iteration 13: log pseudolikelihood = -137.3531
Stoc. frontier normal/half-normal model Number of obs = 291
Wald chi2(21) = 1779.64
Log pseudolikelihood = -137.3531 Prob > chi2 = 0.0000

Robust						
LNOutput	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**	**Interval]**
LNOxendays	0.3024668	0.0775165	3.9	0	0.1505373	0.4543963
LNMandays	0.2149374	0.0675049	3.18	0.001	0.0826303	0.3472444
LNCompost	0.0221437	0.0089916	2.46	0.014	0.0045205	0.039767
LNFertilizer	0.0620407	0.0351236	1.77	0.077	-0.0068002	0.1308817
LNImprovedseed	0.0421137	0.0304755	1.38	0.167	-0.0176172	0.1018447
LNLocalseed	0.1854429	0.0294671	6.29	0	0.1276885	0.2431974
LNInsecticie	0.0309678	0.0176276	1.76	0.079	-0.0035816	0.0655172
LNHerbicide	0.0798451	0.0765632	1.04	0.297	-0.0702159	0.2299062
Sex	0.0501357	0.0534559	0.94	0.348	-0.054636	0.1549074
LNAge	0.2901372	0.2032547	1.43	0.153	-0.1082347	0.6885092
LNAge2	(omitted)					
LNEducation	0.0163711	0.0089927	1.82	0.069	-0.0012542	0.0339965
Maincrop	0.4262037	0.0891983	4.78	0	0.2513783	0.6010292
LNDistancemarket	-0.1257748	0.0664409	-1.89	0.058	-0.2559966	0.004447
Irrigation	0.1504732	0.0654442	2.3	0.021	0.022205	0.2787414
Training	0.3787265	0.1062283	3.57	0	0.1705229	0.5869301
Compulsoryadoption	-0.0946952	0.0531922	-1.78	0.075	-0.1989501	0.0095597
LNLandistance	0.1312072	0.0373624	3.51	0	0.0579783	0.2044361
Credit	0.0612902	0.0553617	1.11	0.268	-0.0472167	0.1697971
LNOffarmincome	-0.0109974	0.0054372	-2.02	0.043	-0.0216542	-0.0003406
DKolatemben	0.7908351	0.1199272	6.59	0	0.555782	1.025888
DWerielekhe	0.114353	0.1032893	1.11	0.268	-0.0880903	0.3167963
_cons	0.7659075	0.7658658	1	0.317	-0.7351618	2.266977
/lnsig2v	-1.89396	0.1220755	-15.51	0	-2.133224	-1.654696
/lnsig2u	-10.17787	0.1784056	-57.05	0	-10.52754	-9.828204
sigma_v	0.3879107	0.0236772			0.3441727	0.4372071
sigma_u	0.0061646	0.0005499			0.0051758	0.0073423
sigma2	0.1505127	0.0183703			0.1145076	0.1865179
lambda	0.0158917	0.0235985			-0.0303604	0.0621439

C) Sorghum

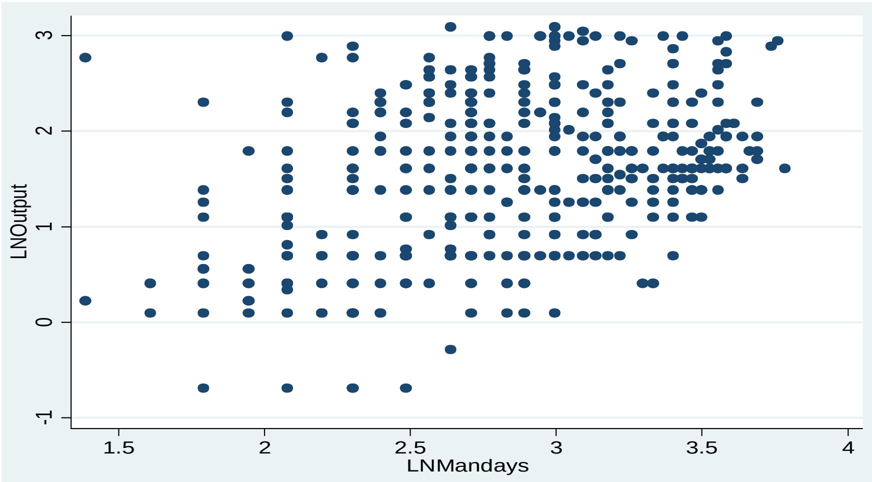
frontier LNOutput LNOxendays LNMandays LNCompost LNFertilizer LNImprovedseed LNLocalseed LNInsecticide LNHerbicide Sex LNAge LNAge2 LNEducation Maincrop LNDistancemarket Irrigation Training Compulsoryadoption LNLandistance Credit LNOffarmincome DKolatemben DWerielekhe. vce(robust)
note: LNAge2 omitted because of collinearity

Iteration 0: log pseudolikelihood = -153.81422 (not concave)
Iteration 1: log pseudolikelihood = -153.7828
Iteration 2: log pseudolikelihood = -153.76078
Iteration 3: log pseudolikelihood = -153.72906
Iteration 4: log pseudolikelihood = -153.72829
Iteration 5: log pseudolikelihood = -153.72554
Iteration 6: log pseudolikelihood = -153.72549
Iteration 7: log pseudolikelihood = -153.72549
Stoc. frontier normal/half-normal model Number of obs = 268
Wald chi2(21) = 640.98
Log pseudolikelihood = -153.72549 Prob > chi2 = 0.0000

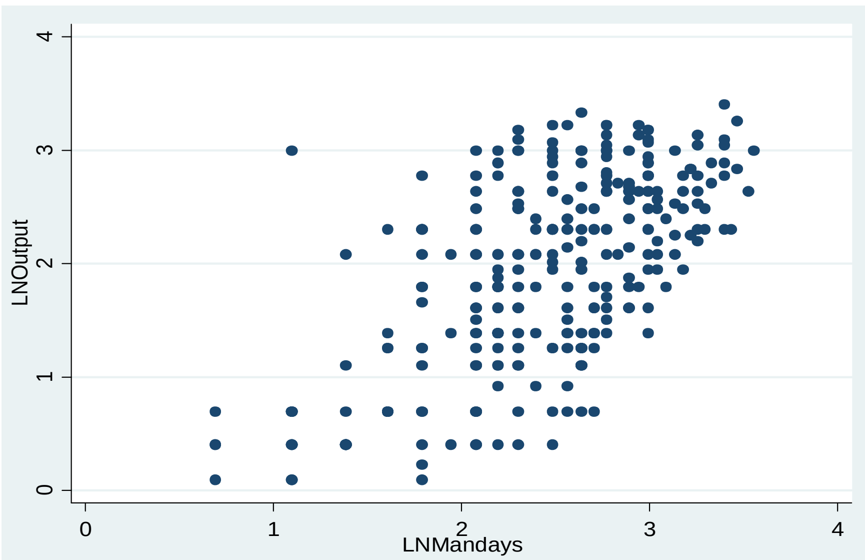
Robust					
LNOutput	**Coef.**	**Std. Err.**	**z**	**P>z**	**[95% Conf.**
LNOxendays	0.3640958	0.0821833	4.43	0	0.2030195
LNMandays	0.2583911	0.0837066	3.09	0.002	0.0943291
LNCompost	0.0299424	0.0092365	3.24	0.001	0.0118392
LNFertilizer	0.0662829	0.027751	2.39	0.017	0.011892
LNImprovedseed	0.1391927	0.0497851	2.8	0.005	0.0416157
LNLocalseed	0.2023589	0.0521265	3.88	0	0.1001927
LNInsecticide	0.0554487	0.0244152	2.27	0.023	0.0075958
LNHerbicide	-0.0875173	0.0459822	-1.9	0.057	-0.1776407
Sex	-0.0302528	0.0712561	-0.42	0.671	-0.1699121
LNAge	0.5028591	0.1846007	2.72	0.006	0.1410484
LNAge2	(omitted)				
LNEducation	0.0170808	0.0126728	1.35	0.178	-0.0077575
Maincrop	0.1945057	0.0825639	2.36	0.018	0.0326834
LNDistancemarket	0.0004059	0.0591524	0.01	0.995	-0.1155307
Irrigation	-0.0582976	0.0969167	-0.6	0.547	-0.2482508
Training	0.0143335	0.0835807	0.17	0.864	-0.1494816
Compulsoryadoption	0.08549	0.0603641	1.42	0.157	-0.0328214
LNLandistance	-0.0387757	0.0382323	-1.01	0.31	-0.1137096
Credit	0.1151666	0.0695694	1.66	0.098	-0.0211868
LNOffarmincome	-0.0126212	0.0050257	-2.51	0.012	-0.0224715
DKolatemben	0.4514125	0.1546374	2.92	0.004	0.1483289
DWerielekhe	-0.4432852	0.1108593	-4	0	-0.6605655
_cons	0.176119	0.7850109	0.22	0.822	-1.362474
/lnsig2v	-1.957292	0.5518952	-3.55	0	-3.038987
/lnsig2u	-2.12298	1.71436	-1.24	0.216	-5.483064
sigma_v	0.3758195	0.1037065			0.2188227
sigma_u	0.3459399	0.2965327			0.0644715
sigma2	0.2609147	0.1302647			0.0056006
lambda	0.9204947	0.3983485			0.1397459

Appendix 3: Scatter Diagram between Output and Man-days

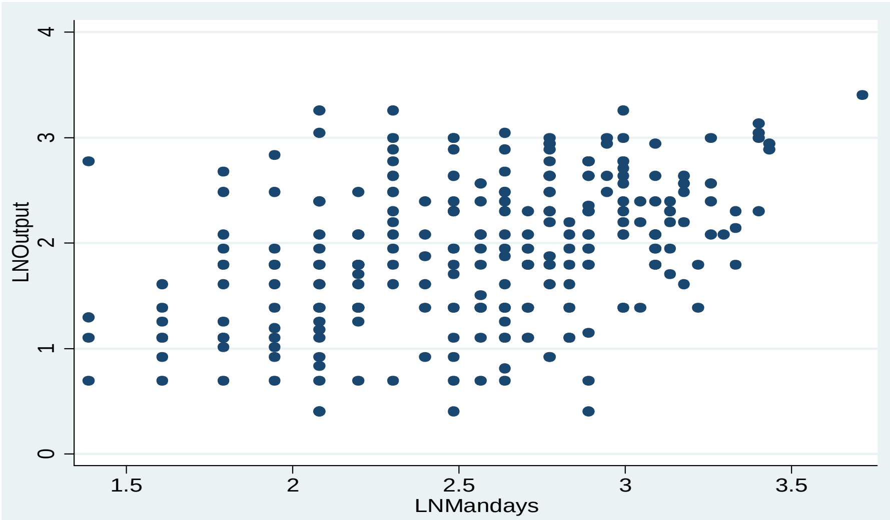
A) *Teff*



B) Maize



C) Sorghum



Analysis of Households Vulnerability and Food Insecurity in Amhara Regional State of Ethiopia: Using Value at Risk Analysis

Mesfin Welderufael[1]

Abstract

This study examines household's food insecurity and the extent of future vulnerability in Amhara region, using WMS and HCES of CSA. Calorie method was employed to determine food insecurity. In addition to descriptive statistics, GLS application for vulnerability and the Logit models was used to analyze the data. The Results indicates that, demand side factor related to socio economic factors like family sizes, education, consumption, employment opportunities and asset ownership was a significant predictor of vulnerability and food insecurity. In rural areas, supply side factors like farm inputs and farm size are also related to food insecurity. Empirical finding also shows that idiosyncratic health-related shocks, covariate economic and environmental shocks have larger impact on vulnerability to food insecurity. Moreover, future vulnerability of households is highly related with current food insecurity, but not uni-directional, particularly in rural areas. Socio-Economic and location differences were also observed in the intensity of vulnerability. It shows that both transitory and chronic food insecurity are highly prevalent in rural areas. The results imply that education, diversification of livelihoods and resources which will raise consumption, will be crucial in attainment of food security. It also strongly supports promotion of family planning; enhancing livestock packages, creation of employment opportunities, delivery of targeting aid for needy groups and input access by

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the poor in the study area. Managements of hazards and risks adequately which enable the poor to escape from vulnerability are immensely vital. Overall, it showed that reducing vulnerability and attaining food security in the region requires adoption of mixed strategies and policies.

Key words: food insecurity, vulnerability, policy intervention, Amhara region
JEL Classification: Q18, I32

1. Introduction

The State of Food Insecurity in the World 2014 showed that About 805 million people were estimated to be chronically undernourished in 2012–14, down by more than 100 million over the last decade. However, about one in every nine people in the world still has insufficient food for an active and healthy life. The vast majority of these undernourished people live in developing countries, with estimated 791 million were chronically hungry in 2014. About one in eight people in these regions, or 13.5 percent of the population, remain chronically underfed. The greatest food security challenges overall remain in sub-Saharan Africa, which has seen particularly slow progress in improving access to food, with sluggish income growth, high poverty rates and poor infrastructure, which hampers physical and distributional access (FAO, 2014). Food insecurity classified as chronic or transitory. Chronic food insecurity occurs when a household is persistently unable to meet the food requirements of its members over a long period of time. It, therefore, afflicts households that persistently lack the ability to either buy food or produce their own. Structural factors contributing to chronic food insecurity include poverty (as both cause and consequence), the fragile natural resource base, weak institutions and inconsistent government policies. It is argued that chronic food insecurity at the household level is mainly a problem of poor households in most parts of the world. On the other hand, transitory food insecurity refers to a temporary decline in a household's access to enough food. It results from a temporary decline in household access to food due to crop failure, seasonal scarcities, temporary illness or unemployment, instability in food prices, production, income or combination of these factors (FAO 2012).

Food security in Sub-Saharan Africa (SSA) is an important issue and has continued to take centre stage in policy discourses. The region has become home to more than a quarter of the world's undernourished people, owing to an increase of 38 million in the number of hungry people since 1990–92. Food availability remains low, even though energy and protein supplies have improved (FAO, 2014). Though food security as a problem at the national level, it was first felt in Ethiopia in the 1960s, it only started influencing policy in the 1980s, when food self-sufficiency became one of the objectives of the Ten-Years Perspective Plan in the early 1980s. This took place after the 1983/4 drought and famine, which claimed millions of lives (Alemu, *et al*, 2002). While efforts to ensure adequate food supplies at the national level have done well, these efforts on their own cannot ensure food availability for households and individuals. One stark indicator of the precariousness of food insecurity in Ethiopia is the rising dependence on foreign food aid. The country receives between 20 % and 30 % of all food aid to sub-Saharan Africa (Bezu and Holden, 2008). In terms of food insecurity, it is one of the top four African countries that constitute more than one third of their populations are under nutritioned in 2014. As a result, About 33 million or 35% of the populations are food insecure, which is far below the SSA average of 23.5% (FAO, 2014). Amhara region, which represents more than 27% of the national population, is one of the regions of Ethiopia suffered from food shortage every year. Most of the region's areas are incorporated under safety net program in order to rehabilitate the farmers' living standard and alleviate their food insecurity problems. However, the region is still characterized by the persistence of food security problems and the need for better intervention. According to the Household Consumption & Expenditure survey (HCES) carried out in 2011, the proportions of households who are food insecure are about 42.5% in Amhara region, much higher than the national average, which is only 33.6 %. The region ranked the highest in the country in terms of food poverty. Food insecurity is relatively higher in rural areas, with about 44.6% and 28% of household's food insecure in Rural and Urban areas, respectively (MoFED; 2012). These all implies that food insecurity is still the persistent problem in the region even after the country has shown economic progress.

In recent years there has been increasing awareness that the analysis of food insecurity should be carried out in a dynamic context. It is essential not just to look at the current incidence of an inadequate nutritional outcome, but also to identify the individuals, households or the communities who are more at risk of suffering in the future. The main analytical concept that has been developed in order to address the issue of the future incidence of food insecurity is vulnerability analysis. The main advantages of the vulnerability approach are twofold. First, the approach is explicitly dynamic and forward-looking, in the sense that it is not simply concerned with current outcomes but looks at their future incidence. Second, the analysis is cast in a stochastic framework and can therefore fully consider the uncertainties associated with future food insecurity, such as the role of external shocks and the strategies that households, communities or public institutions can adopt in order to reduce the likelihood of negative outcomes (Capaldo *et al.*, 2010). Thus it is important to better understand the role of external shocks and the strategies that households, communities or public institutions can adopt in order to reduce the likelihood of food insecurity. Without such knowledge it will not be possible to develop effective policy strategies to tackle this problem. Therefore, the present study tried to investigate the extent of households' vulnerability to food insecurity and determines factors in influencing food insecurity in Amhara regional state at the household level.

From the existing literatures (for instance; Sila and Pellokila, 2007; Shiferaw *et al.*, 2003; Frehiwot, 2007; Frankenberger *et al.*, 2007; Dercon *et al.*, 2005 and Bahiigwa, 1999) it is clear that households food insecurity is associated with a number of socioeconomic and environmental characteristics such as household income/asset, parents' education/occupation, household size, level of Employment, area of residence and access to land holdings, land size and quality. Also policy factors such as the extension services, safety net programs and access to credit have been linked with food insecurity. A review of the literature on the household food insecurity shows that there are limited numbers of studies carried out in Amhara region. There are some studies that have been conducted on determinants of food insecurity in general. In the case of food insecurity, Teshome (2010) measures the proportion of household who are food insecure in nine district of the region. Similar analysis have been undertaken by Arega B. (2012), Lay Gaint using sample survey units and indicated that around 80% of the sampled households were food insecure. This study departs from the above mentioned studies in Amhara region in a number of ways. First, the approach is explicitly dynamic and forward-looking, in the sense that it not only concerned with current outcomes but also looks at their future incidence. There has been a recognition of the need to develop analyses to inform policies that are not only aimed at the currently food insecure but at those who are likely to become food insecure in the future. Second, it will also determine both demand and supply side factors affecting food insecurity in the region. Finally, food insecurity assessments in the Region have traditionally focused on rural areas. Nevertheless, the global increase of food price has put challenges on and increases food insecurity in urban areas. This further driven by rising unemployment and cost of living, low asset ownership, high dependency on the informal sector, and increased population pressure due to rural-urban migration. Thus it is important to better understand urban household's food security status and determinants. With these, the present study was initiated in an attempt to address questions like what are the degree of household's food insecurity and future vulnerability in the study area? What are the covariates of vulnerability to food insecurity? Without such knowledge it will not be possible to develop effective policy strategies to tackle this problem.

2. Literature Review

2.1 Determinants of Households Food Insecurity

Various studies carried out in developing countries have highlighted a number of factors considered as determinants of household's food security. Bahiigwa, (1999) showed that inadequate labour, inadequate land, not growing enough food during the seasons and soil infertility, poor health, lack of planting materials, lack of oxen for plaguing were the main factors contributed to household food insecurity in Uganda. Study by Alarcon *et al* (1993) for smallholder farm households in west highland of Guatemala found that lack of access to credit and cash crop production displace food crops and household consumption of own production is reduced. Thus the household's vulnerability to food insecurity tends to increase. Mucavele (2001) suggested that the main factors that affect food security in urban Maputo, Mozambique, are poverty, low family income, low availability of general alimentation at the family level, floods, family crisis, high unemployment levels and low levels of schooling and training and the absence of a social security system to alleviate the urban shocks. Von Braunet *et al.,* (1993), as stated in FAO, denoted that employment and wages, along with prices and incomes, play the central role in determining the food security status of households. As stated above, the situation in Ethiopia is not much different from the conditions in other developing regions. For example, World Food Programme stated (2009) that the common factors that cause household food-insecurity in urban areas of the country are: household size, age of household, sex of household head, marital status of household, education level of household, dependency ratio, access to credit, ownership of saving account, total income per adult equivalent, expenditure level, asset possession, access to social services, owner of home garden, access to subsidized food, sources of food, availability of food commodities, and supply of food commodities. Shiferaw *et al*. (2003) found technological adoption, farming system, farm size, and land quality are supply-side factors and Household size, per capita aggregate production, and access to market are demand-side factors affecting food security. Teshome (2010) compare the food security situations of the nine districts in Amhara region and the result showed that all the nine districts sample households were vulnerable to food shortage. The study also showed food coverage, landholding, and extension service are the major determinants of sample households. With respect to Amhara region, there are studies by Teshome, 2010; Frehiwot 2007; and Arega, 2012; which showed, as stated above, a mix of factors affecting households' food insecurity in the region.

3. Research Methodology

3.1 Data Sources and Sample Size

The study used data from Household Consumption & Expenditure survey (HCES)[2] and Welfare Monitoring Survey (WMS) conducted by Central Statistics Agency (CSA) in 2011. The surveys gathered qualitative and quantitative data pertaining to social, demographic and economic aspects of households. The HCE survey focuses on the expenditure dimension of poverty through measurement of consumption, expenditure, while the WM survey specializes in the non-income aspects of poverty such as health, education, and access to services. Together, the two surveys paint a complete picture of the poverty and welfare environment of Ethiopia. The WMS information supplements the information obtained from HECS and covers households that are participated in HCES and some other additional households. Accordingly, 5062 and 5085 households were covered in HICE and WM surveys in Amhara region, respectively. However, the present study based on about 4640 sample households (1957 households for rural) covered in HCEs and WMS.

3.2 Method of Analysis

Analysis carried out in two steps; first at Preliminary stage and second at Multivariate. At Preliminary stage, descriptive statistics, and correlation matrix will be construct. Descriptive statistics is used to describe, compare, and contrast various issues related to households with respect to the desired characteristics. In multivariate analysis, the study runs multiple regressions using GLS method for estimates of vulnerability analysis and Logit model for determinants of food insecurity.

In this study, the calorie intake method was used to determine a threshold food security line. Food security is defined as the extent to which total household calorie consumption per Adult Equivalent meets its

[2] In contrast to previous years the "income" component was not captured, making the 2010/2011 an HCE survey rather than an HICE survey.

subsistence requirement. Accordingly, a food poverty line, a threshold level of food consumption expenditure below which an individual is considered to be food insecure are established. Two steps—identification and aggregation—are involved in constructing the index. The food consumption behaviour of the reference group accesses to determine average quantities in per adult equivalent of basic food items that makeup the reference food basket. Identification is the process of defining a minimum level of nutrition necessary to maintain a healthy living. Calorie adequacy was estimated by dividing the estimated calorie supply for each household by the household size, adjusted for adult equivalent, and using the consumption factors for various age–sex configurations.

3.3 Theoretical Approach and Model Specifications

3.3.1 Empirical model for determinants of food insecurity

The theoretical framework underpinning empirical approach of food insecurity is a well-known model in the tradition of Straus (1983), Barnum and Squire (1979), in which a household maximizes a utility function defined over leisure, market-purchased goods& services and home produced goods. Households derive utility from the consumption of foods through the satisfaction found in a set of taste characteristics as well as the health effects of the nutrients consumed. Following Strauss (1983), the household utility function is specified as:

$$U = f\,(F_i, F_m, L) \qquad \mathbf{(1)}$$

Where Fi is home produced goods consumed by the household; Fm is a market-purchase good consumed by the household; and l is leisure. For the sake of simplistic exposition, only two goods and leisure will be considered in the model. Results can be generalized to more goods. The household, as both producer (firm) and consumer, is assumed to maximize its utility from the consumption of these goods subject to farm production, income, and time constraints specified as

$$X = f\,(Qi, L, R, A, K). \qquad \textbf{(2)}$$

$$P(Q_i - F_i) - P_m F_m - w(L - L_f) + N = 0 \qquad \textbf{(3)}$$

$$T = L_f + l \qquad \textbf{(4)}$$

where X is the production function; Q_i is quantities of the goods produced on-farm; L is total labor input to the farm; R is farm technology; A is the household's fixed quantity of land; K is the fixed stock of capital; Pi is price of good i; Pm is the price of a market-purchased good; (Qi-Fi) is marketed surplus of good i; w is the wage rate; L_f is the household labor supply for on-farm use; N is non-farm income which adjusts to ensure that Equation (3) equals zero; and T is total time available to the household to allocate between work and leisure (l).

The income and time constraints can be combined into one by incorporating the time constraint (4) into the income constraint (3) as:

$$Pi\,(Qi - Fi\,) + Pj\,(Q\,j - Fj\,) - Pm\,Fm - w(L - T + l) + N = 0 \quad \textbf{(5)}$$

Rearranging (5) gives

$$P_i F_i + P_j F_j + P_m F_m + w\,l = P_i Q_i + w\,T - wL + N \qquad \textbf{(6)}$$

The left-hand side of equation (6) is the household expenditure on food and leisure, and the right-hand side is the "full" income equation. The expenditure side includes purchases of its own farm-produced good i (PiFi), the household's purchase of the market good (PmFm), and the household purchase of its own leisure time (wl). The full income side consists of the value of total agricultural production PiQi, the value of the household's entitlement of time wT, the value of labor on the farm including hired labor wL, and non-farm income N. The lagrangian is:

$$\text{Max}\ \mathcal{L} = U = f(F_i, F_m, L) + \lambda[P_i Q_i + wT - wL + N) - (P_i F_i + P_m F_m + wL)] + \mu\,[f(Qi, L, R, A,K)] \quad \textbf{(7)}$$

An important property of this model is its reclusiveness in the sense that production decisions are made first and subsequently used in allocating the full income between consumption of goods and leisure (Strauss, 1983). The decision on consumption of the bundle (Fi) is influenced by the decision to produce the quantities (Qi). As a consumer, the household maximizes its utility by equating the marginal rate of substitution between leisure and consumption of good i to w/Pi to the marginal product of labor. The household's supply of labor is determined by the opportunity cost of taking leisure, which is expressed in terms of the marginal product forgone.

Following Strauss (1983), we can mathematically derive the production side and consumption-side equations separately. Starting with the production side, the first order conditions can be solved for the input demand (L) and output supply (Q) in terms of all prices, the wage rate, technology, fixed land, and capital as:

$$L^* = L^* (P_i, w, R, A, K) \qquad \textbf{(8)} \quad \text{and}$$

$$Q^* = Q^*(P_i, w, R, A, K) \qquad \textbf{(9)}$$

These solutions involve the decision rules for the quantities of labor input used and output produced (production-side). Once the optimum level of labor is chosen, the value of full income when profits have been maximized can be obtained by substituting L* and Q* into the right hand side of the income constraint (equation 6) as:

$$Y^* = P_i Q^*_i + w\,T - wL^* + N \qquad \textbf{(10)} \quad \text{and}$$

$$Y^* = w\,T + \pi^*(P_i, w, R, A, K) + N \qquad \textbf{(11)}$$

Where Y* is the "full" income under the assumption of maximized profit π
The first order conditions can be solved for consumption demand in terms of prices, the wage rate, and income as

$$F_k = F_k(P_i\,,\; P_{m,}\; w, Y^*) \qquad \textbf{(12)}$$

Where k = i and m

These solutions involve the decision for the quantities of goods and leisure consumed (consumption demand-side). The three equations (equations 8, 9 and 12) give us a complete picture of the economic behavior of the farm household. They are combined through the profit effect. This will occur in the study region where income is determined by the households' production activities, implying that changes in factors influencing production also changes income, which in turn affects consumption behavior. Incorporating demographic factors (D), the demand for food indicated in equation (12) can be rewritten as:

$$F_k = F_k[P_i ,\ P_{m,}\ w,\ Y^*(w, R, A, K, N\ ), D] \qquad \textbf{(13)}$$

Logit model was used to analyze the determinants of food insecurity status of households. It models the influence of the set of explanatory variables on food security status of households in the study area. Since econometric analysis with cross-sectional data is usually associated with problems of Heteroskedasticity and Multicollinearity, such suspicions were tested using appropriate measures. The explanatory variables of the model were extracted from empirical studies, literature and economic theory. They include socio-economic and demographic characteristics of the household, market and institutional related factors, farm and other characteristics. Prior to the estimation of the logistic regression model, the explanatory variables were checked for the existence of Multicollinearity. Variance Inflation Factor (VIF) was used to measure the degree of linear relationships among the continuous explanatory variables and contingency coefficient was used to check Multicollinearity among discrete variables. Moreover, it is estimated separately for sample rural and urban households. Doing so will be necessary because factors that can account for urban households food insecurity may differ from rural households and the extent may also vary across areas.

3.3.2 The vulnerability model

Conceptually, vulnerability may mean different thing to different individuals. It may mean a situation where an individual feel insecure that something harmful happens in the future. In daily language, ‘vulnerable’ mean something likely to be harmed or wound. Technically, vulnerability is an ex ante measure of well being (Chaudhuri, 2003), i.e., an ex ante expectation of the welfare level of a unit of analysis. In this study, vulnerability is be defined as the extent and probability that household will face food insecurity in the future. The model is based on the Social Risk Management approach (Scaramozzino 2006; Capaldo *et al.,* 2010; Holzmann and Jørgensen, 2000; World Bank, 2000) and, more specifically, on the conceptual framework drawn from it by Løvendal and Knowles (2005). In this framework vulnerability is the result of a recursive process: current socio-economic characteristics and exposure to risks determine households’ future characteristics and their risk-management capacity. At every point in time households’ current food security status is affected by their past status and affects their future status. In this conceptual framework, as in the family of economic models with “overlapping generations”, households have a two-period lifetime consisting of the present (t0) and the future. Present characteristics are known to households and policymakers and determine households’ current food security status. Future characteristics, on the other hand, are unknown to households and policymakers. Between the present and the future (t0-t1), a number of previously unknown factors (i.e. Risks of different kinds) manifest themselves and determine, depending on households’ risk management abilities, the future food security status. The analytical model used here captures the conceptual framework’s recursive structure in two ways: on the one hand it specifies econometrically the relationship between a measure of food security status and a set of household characteristics; on the other hand it explains how current characteristics, risks and risk management capacities affect the likelihood of a favourable (or unfavourable) future food security status.

The approach to the analysis of vulnerability developed by Capaldo *et al.,* (2010), and used in this study is intrinsically dynamic and captures the forward-looking aspects of vulnerability to future risks. The methodology in Scaramozzino (2006), and Capaldo *et al.,* (2010) analysis of vulnerability is using Risk management theory. The most relevant risk management methodology for the measurement of vulnerability in a food insecurity context is the Value-at-Risk (VaR) analysis. This methodology is widely used for the management of the specific risks faced by financial and banking institutions, where it is employed in order to measure the risk associated with an investor's asset and liability position. This problem is akin to the decision faced by households regarding the resources that must be set aside as a contingency against negative future outcomes. VaR is a very flexible tool that can be usefully employed both for measuring and for managing risk. The VaR methodology analyses the probability that the outcome of a risky event might fall below a critical threshold, on the basis of the statistical distribution of all possible outcomes.

Let C denote the food security indicator, which summarizes the food security outcome for a household. Then the household's vulnerability to food insecurity can be defined as the expected welfare loss associated with an inadequate value of the food security indicator, conditional on a number of characteristics of the households, the strategies they put in place, risk management policies implemented by public institutions, and factors outside the control of households and of the public institutions, such as community-wide negative shocks.

The following econometric specification is an ideal specification of vulnerability process. let C_h indicate Household kilocalorie consumption and X_h be a vector of characteristics, such as household size, location, etc. each household's calorie consumption can be expressed:

$$c_h = X_h^{'}\beta = \beta_1 x_{h1} + \ldots + \beta_2 x_{h2} + \ldots + \beta_J x_{hJ} \quad \textbf{(15)}$$

Where is a vector of parameters that are the same for all households. The first step of 3GLS procedure consists of estimating the multivariate equation obtaining estimates of the parameters that explain calorie consumption but for a residual component u = [u_1, u_2………u_n]:

$$C = X\hat{\beta} + u \quad \textbf{(16)}$$

The predicted residuals from (16) are correlated and heteroskedastic; therefore, as a second step, the study assess their dependence on the same explanatory variables through a set of parameters γ. It estimates the equation:

$$u = X\hat{\gamma} + \varepsilon \quad \textbf{(17)}$$

Where ε is the vector of residuals of this second estimation, showing all the desirable properties of residuals that u does not have. From the deterministic part of equation (17) and after correcting again for Heteroskedasticity, derive a consistent estimate of the household variance of food consumption. The variance used to compute each household's vulnerability to food insecurity. Assuming log normality of the calorie consumption distribution, the study estimates the probability that a household becomes Food insecure next period given X, i.e., the vulnerability estimates, as below:

$$\mathbf{Vh} = \mathbf{pr}(\mathbf{lnC}\boldsymbol{h} < LnZ\backslash X = \theta\left[\frac{\mathrm{LnZ}}{\sqrt{\mathrm{varLn(Ci\backslash x)}}} - \frac{\mathrm{E(Ln\,Ci\backslash x)}}{\sqrt{\mathrm{varLn(Ci\backslash x)}}}\right] \quad \textbf{(18)}$$

$$= \boldsymbol{\theta}\left[\frac{\mathrm{Lnz} - \acute{\alpha}\mathrm{X}}{\sqrt{\acute{\eta}\mathrm{Xi}}}\right] \quad \textbf{(19)}$$

Where θ is the operator for standard normal cumulative distribution, ά and ή will be estimated vector of parameters and X will be vector of covariates. The ultimate outcome of the calculations is a set of estimates (one for every household h) of the probability that each household faces of falling below the minimum energy requirement in the future. A household requires minimum of 2200 kcal per day per adult to be food secure. Based on Chaudhuri *et al.*, (2003), a household's vulnerability to food insecurity can be expressed as a probability that household fails to attain the minimum level of calorie intake in the future.

4. Results and Discussions

4.1 Extent of Households Food Insecurity

The results of the summary of the household incidence, depth and severity of food insecurity, are presented in Table 1. The FGT indices namely head count ratio, short-fall and severity of food insecurity are used to show how much the magnitude of food insecurity looks like in the Amhara region. It shows that in 2011 in Amhara region the headcount ratio, short-fall and severity of food insecurity were 48%, 18% and 8.7%, respectively. The results revealed that the incidence of household food insecurity was 0.48. This implies that about 48% of the sampled households were not able to meet the daily recommended caloric requirement[3]. This is different from MoFED (2012), which reports that the incidence of food poverty in Amhara region is about 42%. The difference is basically due to method used to measure calorie consumption and food insecurity. MoFED (2012) used basic needs method to obtain food poverty line; which applied in identifying consumption items defined in 1995/96 that generate 2200 kilo calories valued at 2010/11 national average prices(food and non-food). As the aim of this study is food security analysis (not poverty), it used food energy intake or -calorie method valued at average food price of the region. This method has been applied in several studies with a main focus on food security. The choice among the two methods depends up on the objectives at hand. If the objective is analysis of poverty (food and non-food) across times and regions, the basic needs approach is appropriate. This method is preferred mainly to get a consistent poverty line and analysis (food and non- food) across regions & time. However, if the main focus is food security analysis, calorie energy intake method was appropriate to compute food consumption and its widely used approach in several studies.

[3] Additionally, though not reported here, the calculated calorie consumption of households differ from CSA (2012) and MoFED (2012). This study showed that the mean net calorie consumed in Kcal per day per adult person was 2943 in the region. However, CSA (2012) reported that it was 2145Kcal. The difference is basically the method used to compute calorie consumption. While the computed calorie in this study based on per adult terms which adjusted for sex and age composition of household members, the reports are stated in percapita terms (household size without adjusted for various age and sex compositions).

Table 1: Summary of household incidence and severity to food insecurity

Variables	Total	Rural	Urban
Incidence of food insecurity (Head count ratio)	0.486	0.708	0.341
Depth of food insecurity (Food insecurity gap)	0.18	0.12	0.061
Severity of food insecurity(Squared food insecurity gap)	0.0879	0.062	0.025

Source: Author's calculation from WMS and HCES

The calculated value of food insecurity gap was 18 %. Each food insecure household needs 18% of the daily caloric requirement to bring them up to the recommended daily caloric requirement level besides their per capita consumption and the relative deficiency among food insecure households is 8.7 %. A disaggregated analysis of the extent of food insecurity by location presents a more complete picture of the food consumption pattern of the region. The results of the summary of the household incidence, depth and severity of food insecurity by location of households are also presented in Table 1. Food insecurity was worse in rural household with food insecurity headcount index, short-fall index and severity of 70.8%, 12% and 6.2%, respectively, than the urban counterpart of 34.1%, 6.1% and 2.5%.

Household food security status with reference to various socio-economic characteristics was analyzed in appendix tables (Table A1). The results show that there is significant mean difference between food secure and insecure households with respect to age, dependency ratio, consumption, household size, and access to market. Accordingly, Food insecure households possess more than five of family size and large number of dependents than the counterparts. Dependency ratio shows that higher the dependency ratio more the burden on a household to meet food demand. Mean dependency ratio is less for food secure households than for food insecure households. On average food secure households have three family members with standard deviation of 1.54 while food insecure households have five members with SD of 1.95. Due to poverty and lack of welfare, increasing family size tends to exert more pressure on consumption than it contributes to production. Thus, it affects the food security status of households negatively as food requirements increase in relation to the number of persons in a household. The t value confirmed that both in urban and rural areas there is a significant mean difference between food insecure and secure household.

4.1.1 Food insecurity coping strategies

Coping strategies are activities that households resort to in order to obtain food, income and/or services when their normal means of livelihood8 have been disrupted. Most coping activities are based on the household's endowments and constraints as well as the availability of opportunities. The potential coping strategies practiced in the study areas include reduce the expenditure of the household to the least to buy food, borrow food from relatives, friends and neighbours, and reduction in food consumption frequency in their order of importance. The analysis revealed that most food insecure households, in Amhara region, tend to reduce the quantity of meal per day (62.26%) and turn to the consumption of low quality and cheaper food stuff (54.34%) in times of food deficit. There is significant difference among the locations in terms of use of coping and mitigation strategies.

Table 2: Households' strategies of coping and mitigation of food insecurity by location

Mitigation or coping strategies	Total	Rural	Urban
Minimizing Risks (Reductive Strategy)			
Turn to low quality and cheaper food stuff	54.34	44.14	93.96
Borrow food, or rely on help from friend	44.38	50.07	13.43
Buy food by debt	41.47	43.12	37.43
Absorbing Risk (Depleting Strategy)			
Reducing the quantity of meals	62.26	55.64	72.75
Reduce number and adults' food consumption	40.14	45.15	31.55
Seek alternative income sources	6.74	5.24	9.66
Risk Taking (Maintaining Strategy)			
Skip entire days without eating	9.23	9.8	8.00
Sale of livestock or other assets	12.81	11.2	9.66
Other Alternative Strategies[G]	11.55	10.64	17.67

*This includes out migration, send children for help, begging for money and food and the like.

Households in rural areas, most often depend on reducing the quantity of meals (55.6%), borrow food (50%) and restrict household food consumption to secure the need of children for food strategies (45%). While the coping strategies employed by rural households under conditions of distress are well documented, little is known about how poor households cope with food insecurity in the city. As it is shown in Table 2, the majority of urban households are more likely use less preferred and less expensive (93.9%) strategies.

Additionally, reduce the quantity of food consumption, and borrow food from relatives, friends and neighbours were re reported as consumption smoothing strategies. Disruptive coping strategies such as migration of the family, selling productive assets and begging were practiced more in the urban areas, indicating that food insecurity is a chronic problem in this area where households depend up on purchased foods. This shows that it is advisable to diversify livelihood sources to adapt to food insecurity and promote activities that can increase mitigation capacity of the households.

4.2 Econometric Results for Determinants of Food Insecurity

Table 3 presents determinant factors for household food insecurity in the study area. Logistic regression model was used to identify determinants factors. The dependent variable is household food insecurity which takes a value equal to 1 if household is unable to meet its minimum calorie requirement (2200net kcal per adult equivalent), 0 otherwise[4]. Many studies proved the relevance of household education in reducing household food

[4] Before entering the variables, contingency coefficient was calculated. Contingency coefficient value ranges between0 and 1, and as a rule of thumb variable with value below 0.75 shows weak association and value above it indicates strong association of variables. Since the value for dummy variables was less than 0.75 that did not suggest Multicollinearity problem. Similarly, variance inflation factor of less than 10 are believed to have no Multicollinearity and those with VIF of above 10 are subjected to the problem. The computational results of, the variance inflation factor for continuous variables confirmed the non-existence of association between the variables.

insecurity and malnutrition. In this respect the results indicate that household head education has significant and positive impact on reducing chronic food insecurity in urban and rural areas. This implies the importance of human capital investments in improving household's food security status. The result for rural sample shows that, other things being constant, the odds ratio in favour of being food insecure decrease by a factor of 0.394 as education of the family increase by one unit. This is as expected, since the level of education should positively affect the income earning capacity and level of efficiency in managing the household's food resources. The effect of education on food security works indirectly by influencing the actions of the person in how to make a living. Literate individuals are very ambitious to get information and very curious to accept agricultural or livestock extension services, and soil and water conservation practices including any other income generating activities. The result coincides with the theoretical evidences that educational improvement could lead to awareness of the possible advantages of modernizing agriculture and improve the quality of labour.

Consistent with the hypothesis, the result shows positive and significant influence of household size on food insecurity of a household. This means that each additional member of a household increases household food insecurity. The odds ratio in favour of food insecurity increases by a factor of 2.476 as household size increases by one in rural areas. This finding is consistence with theoretical and empirical. Household size exerts more pressure on consumption than it contributes to production [Shiferaw *et al*., (2003)]. The model also reveals the important role of household consumption expenditure in contributing to household food security as expected. For urban, consumption increases by one Birr odds ratio in favour of being vulnerability to food insecurity decrease by a factor of 0.99, other variables assumed to be constant. This result is in conformity with the findings of Pearce *et al*., 1996; Amsalu *et al*., 2012. The magnitude of coefficient is small suggesting that the impact of annual expenditure must be explained for an increase of 1000 instead of a one birr increase.

Table 3: Logistic results for determinants of household's food insecurity

Variables	URBAN				RURAL			
	Coefficients	**Standard error**	**z-value**	**odds –ratios**	**Coefficients**	**Standard error**	**z-value**	**odds -ratios**
household size	0.8092***	0469	17.22	2.2463	0.9066 ***	0.0655	13.83	2.476
age of household	0 .0021	0 .0036	0.59	1.0021	0.0091**	0.0040	2.28	1.0091
sex of households(male)	0. 3703***	0. 1224	3.03	0 .6904	0 .3073*	0.1654	1.86	1.3598
real percapita expenditure	-0.0001***	0.00002	-4.76	0 .9998	-0.0002***	0.00004	-3.77	0.9998
ownership of house	0. 1525	0.1234	1.24	1.1647				
household education	-0.0522***	0. 0114	-4.56	0.9491	-0.0668**	0.0319	-2.09	0.9353
livestock (TLU)	-0.02901	0 .0208	-1.39	0.9714	-0. 0521**	0.0261	-1.99	0.9492
unemployed	1.010*	0 .6098	1.66	2.748				
access to micro-credit	0. 0971	0. 1767	0.55	1.1020				
access to market	- 0.1021***	0. 0290	-3.52	0 .9028	0 .0109	0.0068	1.60	1.011
price shocks	0 .1457	0 .1938	0.75	1.1569				
remittances	-0.6958***	0 .2396	-2.90	0.4986				
off-farm activity					0.1447	0.2866	0.50	1.1557
farm size					-0.0256*	0.01507	-1.70	0 .9746
agricultural extension services					-0.1093	0.1675	-0.65	0.8963
local migration network					-0.3792**	0.1630	-2.33	0.6843
use of fertilizers					-0.1374	0.1631	-0.84	0.8716
dummy for Drought shock					1.3660**	0.5612	2.43	3.9199
dummy for illness					0.436	0.3213	1.36	1.5466
constants	-2.0952***	0 .3690	-5.68	0.123	-1.9832***	0.4039	-4.91	0.1376
number of observations	2460				1803			
Wald chi2(12)	474.19***				320.51***			
Pseudo R^2	0.3631				0.362			
Sensitivity	68.12%				92.05%			
Specificity	91.07%				62.40%			
Correctly classified	83.37%				83.69%			

Note: Standard errors are Robust standard errors and significant at * $p<0.1$; ** $p<0.05$; *** $p<0.01$

Physical access to market as proxied by time spent to get to the market was also found to have a negative and significant relationship with food security, indicating that the farther the household is away from the market place and information about market prices, the less likely the family is food secure. Access to employment opportunities help to diversify and increase amount of income received by households. The fluctuation in access to employment determines food insecurity of urban households. The Odds-Ratio shows that other things remaining equal, the odds ratio in favour of food insecurity increases by a factor of 2.748, as Household become unemployed. This result confirms the finding of Mucavele, 2001 and Von Braun *et al* (1993) the sign of the coefficients of age and sex of the household head showed a positive relationship with food insecurity. The interpretations of the results require great caution; they cannot be interpreted as correlations and needs further disaggregate analysis. As stated in the next part, widowed women are more vulnerable and thus more likely to face reduced food consumption. However, the puzzling results are not uncommon (for instance, Frehiwot, 2007; find the same results for age in rural Amhara and Amsalu *et al.,* 2012, for sex of households). Similarly, livestock size is negatively and significantly associated with the probability of being household vulnerability to food insecure. The result indicates that, other things held constant, the odds ratio in favor of being food insecure decrease by a factor of 0.9492 as the total livestock holding increase by one TLU. This result is in agreement with the prior expectation and the findings of Shiferaw *et al* (2003). The negative relationship is explained by the fact that households with large herd size have better chance to earn more income from livestock production. This in turn enables them to purchase food when they are in short of their stock, and invest in purchase of farm inputs that increase food production, and thus ensuring food security at household level. The result with regards to the Access to off-farm work was found to be in contrary with what we were expecting for. Access to off-farm work did not have a significant impact on the probability of household food security. The low magnitude of the "partial" effects is most probably related to the low level of wages and unavailability of jobs as needed. The coefficient of farm size is negative in sign and statistically significant at the 10% level, meaning that farm size exhibits a negative relationship with the food insecurity status of a household. That is, households with larger farm sizes tend to be more food secure than those with smaller sizes, and vice versa. This means households with large cultivated land produce more for consumption and for sale and have better chance to be food secure than those having relatively small size of cultivated land[1].

In rural areas, where the farmers face crop failure and livestock product is inadequate, transfer income earned from relatives and migrated household member are an important means of acquiring food. Accordingly, the success of farm households and their family members in coping with food insecurity is highly determined by their ability to get access to migration network opportunities. The result suggests that household's accesses to remittances are endowed with additional income and less likely to be vulnerable to food insecurity. This is plausible because households that have other sources of income in addition to farming alone tend to be more resilient in times of food crisis than those engaged in farming alone. Finally, Consistent with the hypothesis, vulnerability of rural households to food insecurity is likely to increases with shocks faced by the households like illness, drought, crop failure and others. It indicates that, the odds ratio in favour of being food insecure increases by a factor of 3.9199 as the as Household faced drought. This confirms the importance of reducing the malign effect of shocks is as to reducing poverty.

4.3 Estimates of Households' Future Vulnerability to Food Insecurity

The regression estimates of the models of per adult calorie consumption and the variance of consumption are stated appendix (Table A2). The study

[1] Shiferaw *et al.*; 2003, observed that greater efficiencies in the use of resources are associated with the large farms than the small farms. They pointed out that the smallness of holdings deters the use of modern technology. This results in low productivity and low income, and consequently incidence of food insecurity among the farm households.

employs three regression specifications in order to estimate expected per capita calorie consumption and its variance. The first (left-hand panel) is a total one for all size in which household demographics, preferences, assets, access to infrastructure, incidence of shocks and coping capacity are used as explanatory variables for per adult capita food consumption. The second is rural specification (middle), incorporates variables that capture agriculture-specific features since this is the dominant livelihood activity in rural areas and the third specification (right-hand panel); incorporates variables that capture urban specific features. Discussion of the parameter coefficient is beyond the purview of the present research, but some results are worth pointing out.

As shown in appendix, variables related to household demographics and assets perform as expected. Assets and human capital positively contribute to higher levels of calorie consumption, in all specifications; widowed households are more vulnerable and thus more likely to face reduced food consumption in the future, whereas female headed households are likely to consume more kilocalories percapita. Consistent with logit estimation, household size are negatively related with calorie consumption of the households. Ownership of assets and quality of houses are positively affect food consumption on households. In particular, ownership of mobile, sturdy roof, the number of rooms in a home use (an approximation of household wealth), have the largest positive correlation with the level of food consumption. Idiosyncratic health shocks and Covariate climate & economic shocks have negatively affects per capita calorie consumption of the households, with specific to rural and urban areas. As expected, schooling of household shows the usual positive and sheepskin effect on household calorie consumption. In both areas of households, education of household head has positive impact on calorie consumption and the coefficient is significant both in rural and urban areas. As is generally established, education provides individuals with greater ex-post risk coping ability and the findings from different studies confirm such a view. Literatures show that additional income received increases the stable income so that capacity of the households to consume more will increase. Thus, the additional income received increases the stable income so that capacity of the households to consume more will increase. With these, Households with migrant family members in rural areas and access to remittances in urban areas significantly determine food consumption and face smaller variance in their food consumption. This possibly indicates the positive impact of remittances on food consumption resulting from a more diversified income. The result is in line with above finding and standard economic theory on domestic migration. Better access to public infrastructure also positively correlates with food consumption; increased distance from a public road is strongly linked to a reduction in the level of food consumption. However, the greater distance from a public road is also associated with lower variance in food consumption, possibly indicating low transmission of market volatility. This result is robust across all regression specifications. The positive association between 'access to assistance programs' and variance in food calorie consumption, though not significant, may reflect poor targeting or design imperfections, as frequently discussed in the literature. The results are not statistically significant, possibly because of the binary specification of the variables, which means that there is limited information on the amount and intensity of the assistance that each household has experienced.

Covariate shocks, particularly weather-induced fluctuations in production and idiosyncratic health shocks are the main drivers of increased vulnerability of farm households. This suggests that households exposed to higher yield risk—presumably associated with adverse local geo-climatic conditions—tend to have lower long-term consumption levels after controlling for a wide range of other household characteristics. Additionally, covariate economic shocks, price shock, are negatively effect on per capita per adult calorie food consumption and significant in first and urban specifications. This show in urban areas as households depend on purchased food consumption, an increase in price will significantly affect the consumption. These findings are important for policy interventions in rural and urban Amhara region. Since budget is necessarily constrained, programs should be targeted toward the most vulnerable people. To do so, specific area profiles can provide valuable information on the impact of both idiosyncratic and covariate shocks on vulnerability either it observable or unobservable shocks. Finally, in the rural areas, land ownership explains the strong positive impact of land ownership on food consumption and negative on its variance. Consistent with the logit estimation, the larger the size of cultivated lands the lower the volatility in food consumption. On the other hand, the livestock ownership has a significantly positive impact on food consumption, suggesting that households that earn part of their livelihoods from marketing their agricultural produce are less vulnerable to becoming food insecure. Possession of livestock seems to be a good insurance instrument against food shocks.

Based on the regression analysis, the vulnerability indicator is computed using predicted kilocalorie consumption and its variance for each household in each of the three specifications. Moreover, an arbitrary threshold of 0.5 (standard in the literature) at and above which a household is considered vulnerable is chosen. Accordingly, the degree of households' vulnerability to food insecurity was estimated using the method stated in the data analysis part[2]. In line with Chaudhuri (2003), choosing the focal point to be 0.5 where the household becomes vulnerable to food insecurity, it revealed that about 52% of the sampled households in Amhara region were found to be vulnerable to food insecurity in the future, whereby the average probability for a household to fall below the food insecurity threshold is about 51.8 percent. The analysis of vulnerability to food insecurity indicates that in the rural areas the average degree of vulnerability is about 76%, which is much higher than the region average. However, urban households are supposed to be less vulnerable to food insecurity, with mean vulnerability of 32.1%) compared to the rural one. The analysis shows that, estimates of mean and incidence of vulnerability are much higher in rural than in urban areas of the region. This is common in standard poverty analysis, rural areas always fare worse than urban and the conclusion is not different in food insecurity vulnerability assessment.

[2] Since the main purpose of this study is to analyze and estimate vulnerability, the study ignores possible econometric complications that are not directly relevant.

Table 4: Probability of falling into a state of food insecurity in the future in Amhara region

	Amhara Total		Rural		Urban	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Vulnerability	0.518	0.419	0.763	0.341	0.321	0.373

Source: Author's calculation from WMS and HCES

The relationship between current food security status and vulnerability to food insecurity revealed statistically significant association between the two (Table 5). It indicates that the average degree of vulnerability in the study area is about 52.3%. With this, of the current food insecure households, about 84% are chronically food insecure or likely to remain insecure in the future (vulnerable) where as the remaining are not vulnerable to future food insecurity. On the other hand, about 20.8% of the current food secure households are vulnerable to food insecurity (likely to be food insecure in the future) in the Amhara region. The result also brings to light the fact that vulnerability in terms of food insecurity prospects is largely a rural phenomenon. Households in rural areas of the region are highly vulnerable to both transitory and chronic food insecurity and, of the current food insecure households in rural areas, about 93% are likely to remain food insecure in the future (vulnerable) where as only about 57.3% current food secure households are not vulnerable to future food insecurity. In the other case, only about 6.5% of the rural households are food insecure but non-vulnerable to food insecurity in the future. There is statistically significant difference in vulnerability to food insecurity across the current food status and locations of the households. This indicates that district specific coping strategies are needed. Hence, food security intervention programs needs to give priority to highly vulnerable areas where there are no diversified livelihood mechanisms.

Table 5: Percentage distribution of current food security status and vulnerability to future food insecurity

	Amhara total				Rural sample			
Current status:	**vulnerable**	**non-vulnerable**	**total**	χ^2	**vulnerable**	**non-vulnerable**	**total**	χ^2
Food insecure	84.64	15.36	49.38	2.1***	93.45	6.55	70.98	580.6***
Food secure	20.77	79.23	50.62		42.61	57.39	29.02	
total	52.31	47.69	100		78.69	21.31	100	

Source: Author's calculation from WMS and HCES

A cursory look at Table 6 also reveals that those with current, food insecure, are the ones mostly vulnerable and with the highest incidence. As the table shows, only 40.1% of total households enjoy stable levels of food security in Amhara region; that is they are food secure and not vulnerable. On the other hand, 41.79% of the population is undernourished (food insecure) while also being vulnerable; these are considered chronically food insecure. 7.6% of households are currently undernourished but only temporarily (transient food insecure). Most importantly, about 10.52% of households in total sample are food secure at present, while being at risk of being undernourished (food insecure) in the future. Therefore, in the case of interventions a targeting error could potentially affect about one fifth of the population (10.52%+7.6%=18.12%). Forward-looking analysis of vulnerability to food insecurity allows correcting these potential errors in policy design.

Overall, in about 52.31% of sample households are vulnerable to food insecurity, exhibiting an average vulnerability of 89%. The situations are very severe in rural areas; with about 78% sample households are vulnerable to future food insecurity, exhibiting an average vulnerability of 93%. Further, Decomposition of vulnerability into rural and urban households, show that only 4.65% of the sampled rural population is in a transitory condition, falling in and out of food insecurity, while the remaining are found to be in a stable condition, being either food secure or food insecure. Most importantly, about12.36% of households in rural sample are food secure at present, while being at risk of being food insecure in the future;

while its about 8% in urban areas. On the other hand, about 66.3% and 23% of rural and urban households are chronically food insecure respectively, i.e, they are food insecure while also being vulnerable. This again highlights the fact that vulnerability in terms of food insecurity prospects is largely a rural phenomenon. Food security-oriented policies based on a static analysis of food security (emphasizing current vulnerability) may not capture the imminent needs of a large share of the population, while targeting households whose needs are of a temporary nature only. The results also show a positive relationship between vulnerability to food insecurity and households' dependence on farming activities. The estimates also suggest that there is no bi univocal correspondence between current undernourished households and vulnerable ones. The two groups overlap but are not identical. Consequently, policy measures based on static food security analysis would include errors of exclusion and of inclusion; resources would be directed to undernourished households, a large proportion of which are unlikely to remain insecure even without assistance, while those households currently sufficiently well-nourished are vulnerable to future food insecurity.

Table 6: Distribution of household shares by current and future vulnerability to food insecurity[G]

	Amhara Total			**Urban**			**Rural**		
Current status:	**(Food Insecure In Future)**	**Vulnerable Food Secure In Future)**	**Total**	**(Food Insecure In Future)**	**Vulnerable (Food Secure In Future)**	**Total**	**ood Insecure In Future)**	**Vulnerable (Food Secure In Future)**	**Total**
	(Vh [0.5)	**(Vh Y 0.5)**		**(Vh [0.5)**	**(Vh Y 0.5)**		**(Vh [0.5)**	**(Vh Y 0.5)**	
Food	41.79	7.6	49.38	23.05	10.58	33.63	66.33	4.65	70.98
insecure	[0.93]	[0.2]	[0.81]	[0.87]	[0.18]	[0.65]	[0.95]	[0.23]	[0.90]
Food	10.52	40.1	50.62	8.11	58.26	66.37	12.36	16.66	29.02
secure	[0.78]	[0.09]	[0.23]	[0.731]	[0.072]	[0.15]	[0.82]	[0.14]	[0.43]
Total	52.31	47.69	100	31.16	68.84	100	78.69	21.31	100
	[0.89]	[0.11]	[0.52]	[0.84]	[0.09]	[0.32]	[0.93]	[0.16]	[0.76]

Source: Author's calculation from WMS and HCES ∗In brackets, average probability of vulnerability, vh)

4.3.1 Shocks and vulnerability status of households

The probability of becoming food insecure in the future is determined by the present conditions, the risks potentially occurring within a defined period and the capacity to manage the risks. What happened yesterday is reflected in today's status and what happened today influences tomorrow's status. Risk factors threaten food security today and cause vulnerability. Crop production risks, such as crop failure due to pests and diseases, livestock dearth, drought, and volatility of income were the major features of rural households. Rural poor households are much more exposed to natural disasters and agricultural-related shocks, while the urban-poor are found to be more vulnerable to economic shocks specific to the formal economy. Since urban and rural households face different prices particularly for food stuff, and given the pre-eminence of expenses on food in total household income, across areas may be inflating vulnerability incidence. Covariate shocks, particularly weather-induced fluctuations in production and idiosyncratic health shocks are the main drivers of increased vulnerability of farm households /rural households. The test results presented in Table 7 also shows that there is a systematic association between vulnerability and the incidence of each predictor variables. Households that have been exposed to a shock have higher levels of vulnerability compared to households that have not, suggesting a difficulty in recovering from these and a need to strengthen risk management capacities. In particular, Drought frequently affected rural population and has the worst outcome in terms of increasing the average probability that a household will be undernourished, taking their vulnerability to the relatively higher levels; the average probability is 93 %; which is 13 percentage points higher than households that have not experienced drought shocks. An illness of a member of the household households that have experienced illness have a 82 % probability to be food insecure in the near future, which is 6 percentage points higher than households that have not experienced an illness.

In sum, the common truth from the above analysis is that rural households' vulnerability stems from idiosyncratic health and disease shocks and covariate climate shocks, which are translated into low average living standards, while urban households' vulnerability is largely explained by high volatility in living standards which arising from idiosyncratic health and Covariate economic shocks which are specific to the formal economy. This shows risks are different and more diverse, particularly for the poor who are usually unable to participate fully in the economy and resources that could mitigate their situation in times of need.

Table 7: Estimates of mean and incidence of vulnerability of households by shocks

Locations	HH affected by shocks		
	yes	no	t-stat
	Mean vulnerability	Mean vulnerability	
Rural Sample			
drought	0.93	0.76	-3.39***
illness	0.82	0.76	-1.64*
income volatility	0.80	0 .76	-0.83
crop damage	0 .85	0 .76	-1.89**
flood	0 .86	0.76	-2.34***
livestock Losses/dearth	0 .89	0 .76	-2.71***
Involuntary loss of land	0.877	0.764	- 0.662
Urban Sample			
price shock	0.359	0.318	-1.579*
illness	0.497	0.317	-3.91***
income volatility	0.334	0.324	-0.49

Source: Author's calculation from WMS and HCES

With regard to education Table 8 reveals that; those with no formal education are the ones mostly vulnerable and with the highest mean incidence. Educated people can adapt more easily to changing circumstances, therefore showing greater ex post coping capacity. Almost 63 per cent of those with no schooling are vulnerable compared to a 19.5 per cent for those with university degree. Besides, in rural areas more than 90 per cent of those belonging to the group with no formal education and less than secondary enrolment are chronically poor or trapped into food insecurity. These results were in any case expected and confirm the well established hypothesis of the negative correlation between vulnerability and education (Schultz, 1975; Christiansen and Subbarao, 2005). This makes clear that policies that aim at improving and stabilizing household's income streams in the medium and long term would better achieve its goal through accumulation of human capital, specifically education.

Table 8: Vulnerability estimates by educational attainment

Educational level	**Amhara Total**			**Rural sample**		
Read and Write	**Mean vulnerability**	**vulnerability incidence (vh > 0.5)**	¡^{2}	**Mean vulnerability**	**vulnerability incidence (vh> 0.5)**	¡^{2}
Yes	0.42	43.86	142.3***	0.789	81.14	
No	0.60	61.32		0.750	77.51	3.36*
Total	0.52	52.31		0.763	78.68	
Educational Attainment						
No Schooling	0.625	63.68		0.76	78.72	
Primary	0.544	54.92	510.8***	0.795	81.80	49.3***
Secondary	0.217	20.93		0.33	32.14	
University Or Higher	0.209	19.53		0.20	20.0	

Source: Author's calculation from WMS and HCES

Numerous studies have shown a statistically significant positive association between total household per capita income and dietary diversity. The close association between income and diets can be shown by using household consumption. The following table shows the distribution of households' vulnerability in terms of the lowest (Q1) and highest (Q5) quintiles according to per capita consumption expenditure. Households having higher income are obviously less likely to be food insecure, as compared to households with low income. Households with high income can spare more money on food after meeting other needs. Higher physical wealth/income reduces transient as well as chronic poverty and food insecurity. Results given in Table 9 show, out of total households from the lowest quintiles group (the lowest 40%), over three-quarters (76.2%) of them are vulnerable to food insecurity, with mean vulnerability of more than 80percent.

Table 9: Vulnerability estimates by consumption quintile total and urban sample

Consumption Quintiles	Amhara Total	Urban Sample			
	Mean Vulnerability	Vulnerability Incidence (Vh > 0.5)	Mean Vulnerability	Vulnerability Incidence (Vh > 0.5)	¡^{2}
Quintile 1	0.82	84.64	0.64	66.22	
Quintile 2	0.74	76.22	0.53	54.49	
Quintile 3	0.61	63.04	0.42	40.84	
Quintile 4	0.49	48.42	0.32	29.49	458.1***
Quintile 5	0.20	18.66	0.14	11.96	

Source: Author's calculation from WMS and HCES

Looking at the vulnerability ratio across consumption groups, it has a monotonic relationship with vulnerability. In all cases they are smaller for the least vulnerable class than for the most vulnerable one Vulnerability is more concentrated (i.e. widespread) at lower levels of quintile (Table 9). More than 66 percent of the first quintile poor households in the urban areas are vulnerable to food insecurity while less than 12 percent of the richest quintiles are vulnerability; shows low income prospects of vulnerability. The underlying truism that you pay for most of your needs in the city makes income indispensable for household food insecurity, particularly given that most poor urban households are net food purchasers. Similarly, chi-square tests for the variables indicate that greater proportions of less vulnerable households are from high consumption quintiles in urban areas. Decomposition of vulnerability into income prospects sets clear that relatively high level of consumption inequality among urban households which results in higher incidence of vulnerability.

5. Conclusions and Implications

Understanding the causes and level of food security would help policy makers to design and implement more effective policies and programs for the poor. Food security interventions based on static food security analyses do not capture the imminent needs of a potentially large share of the population that is likely to change its food security status in the near future, particularly in rural areas. It appears necessary to understand why transitorily or structurally poor households are exposed to volatility that may contribute to vulnerability. The purpose of this study was to carry out empirical estimation on household food insecurity and future vulnerability in Amhara region. An attempt has been made to identify factors that determine the household food insecurity. The study also examines factors related to why transitorily or structurally poor households are exposed to food calories consumption volatility which will contribute to vulnerability. A two-stage process involving the application of the vulnerability model and the Logit model was employed to analyze the data. Accordingly, the study revealed that almost about half of the households were not able to meet the daily recommended caloric requirement. Further, the descriptive statistics shows that there was evidence of location and socio-economic differences in intensity of food security. There are significant mean difference between vulnerable and non-vulnerable households with respect to various demographic, socio-economic variables and incidences of risks. The Results indicate that for both rural and urban households, demand side factor related to demographics like family sizes, age, dependency ratio, marital status, socio economic factors including education, consumption, alternative employment opportunities and asset ownership was a significant predictor of vulnerability and food insecurity. It is found that, vulnerability to food insecurity is negatively associated with wealth/asset holding, human capital and alternative source of income for households. This shows, Ownership of household assets is considered to be one of the strategies for enhancing households' resilience in the face of economic crisis and adverse circumstances, such as crop failure, drought, and so on. In rural areas supply side factors like farm inputs and farm size, as well as environmental shocks are related to vulnerability and food insecurity. Empirical findings also show that idiosyncratic shocks, in particular health-related shocks, covariate economic and environmental shocks have larger impact on vulnerability to food insecurity. The vulnerability analysis also shows differences in the intensity of future vulnerability among rural and urban areas. It clearly reveals that vulnerability to food insecurity is still mainly a rural phenomenon and that this is induced by so many factors. Moreover, future vulnerability of households is highly related with current food insecurity, but not uni-directional, particularly in rural areas.

From a policy perspective, the results of the study have a number of implications. It implies that expansion of education, diversification of livelihoods and access to resources which will raise consumption, will be important in reduction of vulnerability and attainment of food security in the region. The more household head educated, the higher will be the probability of educating family member and familiar with modern technology, which the twenty first century so badly demands. So, strengthening both formal and informal education and vocational or skill training should be promoted to reduce food insecurity in the study area. This finding also strongly supports that promotion of family planning in order to reduce the increasing pressure on the available scarce resource; enhancing livestock packages, creation of employment and income generating opportunities, delivery of targeting aid/safety net for emergency needy groups, input access by the poor can mitigate vulnerability to food insecurity in the study area. Management of shocks and risks adequately which enable the rural poor to adopt suitable livelihood strategies is important to an escape from food insecurity. Moreover the policy initiatives that will do most to enhance the potential for self-employment, stabilization of covariate economic shocks and alternative income opportunity are basic in reducing vulnerability in the urban areas. In general, the results of this study produce the implication that reducing vulnerability and attaining food security in the urban and rural areas of Amhara region requires adoption of mixed strategies and policies.

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Appendices

Table A1: Association between household food security status and selected predictor variables

Variables	Food security status	Total Mean [SD]	Urban Mean [SD]	Urban t [P-Value]	Rural Mean [SD]	Rural t [P-Value]
family size	FS	2.939 [1.545]	2.56 [1.294]	-38.4*** [0.0000]	2.84 [1.42]	-29.3*** [0.0000]
	FI	5.302 [1.954]	4.762 [2.077]		5.46 [1.899]	
average annual percapita Expenditure	FS	7892.88 [10398.7]	10342.23 [18122.9]	10.7*** [0.0000]	6886.78 [3768]	18.3*** [0.0000]
	FI	4396.72 [2868.40	5455.68 [4469.55]		4299.4 [2653.1]	
kcal consumption/adult/day	FS	3900.75 [1903.7]	4576.15 [2426.15]	37.6*** [0.0000]	3623.3 [1560.2]	51.1*** [0.0000]
	FI	1293.5 [455.55]	1541.33 [421.461]		1270.8 [451.8]	
dependency ratio	FS	0.7382 [0.767]	0.481 [0.646]	-9.9*** [0.0000]	0.843 [0.788]	-8.4*** [0.0000]
	FI	1.153 [0.772]	0.784 [.742]		1.18 [0.76]	
age of household head	FS	43.377 [18.995]	36.78 [16. 31]	-11.8*** [0.0000]	46.06 [19.36]	-0.47 [0.317]
	FI	46.304 [14.416]	44.30 [14.84]		46.48 [14.36]	
distance to the nearest market	FS	5.926 [8.882]	1.145 [2.10]	0.25 [0.601]	7.879 [9.8]	-1.59* [0.0551]
	FI	8.175 [10.67]	1.125 [1.615]		8.81 [10.9]	

Source: Author's calculation from WMS and HCES

Table A2: Regression results for calorie consumption and variance of calorie consumption

Variables	Total Amhara Sample		Rural Sample		Urban Sample	
	Log pc kcal consumption	Variance of consumption	Log pc kcal consumption	Variance of consumption	Log pc kcal consumption	Variance of consumption
Female headed HH	0.18***	-0.12	0.08**	0.06	0.22***	-0.14
	(0.02)	(0.09)	(0.03)	(0.19)	(0.02)	(0.11)
Female head of HH is widow	-0.11***	0.07	-0.12***	-0.13	-0.09***	0.22
	(0.02)	(0.13)	(0.04)	(0.23)	(0.03)	(0.16)
Log HH size	-0.72***	-0.25***	-0.82***	-0.11	-0.70***	-0.40***
	(0.01)	(0.07)	(0.02)	(0.12)	(0.02)	(0.09)
Log age of HH head	-0.09***	-0.19*	-0.17***	-0.15	-0.05**	-0.05
	(0.02)	(0.11)	(0.03)	(0.16)	(0.03)	(0.15)
Access to safe water	-0.001	-0.02	0.01	0.13	-0.01	-0.02
	(0.02)	(0.09)	(0.03)	(0.15)	(0.02)	(0.11)
Access to assistance Govt/NGO	-0.01	0.05	0.03	0.01	-0.01	0.17
	(0.02)	(0.09)	(0.02)	(0.11)	(0.02)	(0.14)
dummy for Price shock	-0.07***	-0.06	-0.03	-0.08	-0.06**	-0.02
	(0.02)	(0.13)	(0.04)	(0.19)	(0.03)	(0.17)
dummy for drought	-0.19***	-0.32	-0.13**	-0.23		
	(0.06)	(0.31)	(0.06)	(0.34)		
dummy for Illness	-0.08**	0.26	-0.04	0.35	-0.11**	0.33
	(0.03)	(0.18)	(0.04)	(0.24)	(0.05)	(0.29)
access to Small loan	-0.02	-0.09	0.02	-0.23	-0.03	0.15
	(0.02)	(0.10)	(0.03)	(0.15)	(0.03)	(0.14)
Log no livestock owned (TLU)	0.01*	0.03	0.03***	0.02	0.002	0.04
	(0.01)	(0.03)	(0.01)	(0.05)	(0.01)	(0.04)
Log years of education of HH	0.06***	-0.06	0.05***	0.02	0.07***	-0.01

	(0.01)	(0.04)	0.01	(0.08)	(0.01)	(0.05)
Log distance to nearest major road	-0.03***	-0.02	-0.03***	-0.01	-0.02*	-0.01
	(0.01)	(0.04)	(0.01)	(0.04)	(0.01)	(0.07)
Log land owned (ha)	-0.002	-0.01	0.05***	-0.09	-0.01	0.10
	(0.01)	(0.07)	(0.02)	(0.10)	(0.02)	(0.11)
cement floor	0.06***	0.02	0.35*	0.59	0.04*	0.10
	(0.02)	(0.12)	(0.19)	(1.02)	(0.02)	(0.13)
Log time to nearest health facility	0.01***	-0.02	0.02**	0.03	0.01**	-0.03
	(0.01)	(0.03)	(0.01)	(0.05)	(0.01)	0.03
sturdy roof	0.10***	-0.29***	0.13***	-0.33**	-0.004	-0.01
	(0.02)	(0.10)	(0.02)	(0.13)	(0.04)	(0.22)
log no, of mobile owned	0.08***	-0.19	0.24	-1.46	0.01	0.17
	(0.02)	(0.13)	(0.17)	(0.91)	(0.03)	(0.14)
Log no of radios owned	0.03	0.04	0.03	0.03	0.02	-0.01
	(0.02)	(0.11)	(0.03)	(0.14)	(0.04)	(0.19)
Log no of TVs owned	-0.01	-0.13	-0.03	-8.90***	-0.002	-0.09
	(0.03)	(0.19)	(0.06)	0.33	(0.04)	(0.24)
ownership of electric mitad	0.07*	-0.50**			0.02	-0.34
	(0.04)	(0.20)			(0.04)	(0.21)
Log distance to nearest primary school	-0.001	0.04	-0.01	-0.03	0.01	0.07
	(0.01)	(0.03)	(0.01)	(0.05)	(0.01)	(0.06)
Log no of bikes owned	-0.13	-0.45	-0.46	-88.43***	-0.14	-0.46
	(0.14)	(0.75)	(0.61)	(3.28)	(0.14)	(0.77)
Log no of rooms	0.07***	-0.09	0.01	0.13	0.05**	-0.09
	(0.02)	(0.08)	(0.03)	(0.14)	(0.02)	(0.11)
off-farming activities	0.03	0.05	-0.02	-0.02		
	(0.02)	(0.12)	(0.04)	(0.23)		
Access to HH migration network	0.10***	-0.07	0.10***	-0.17		

	(0.01)	(0.08)	(0.02)	(0.12)		
use of fertilizers			0.02	-0.18		
			(0.03)	(0.15)		
agricultural extension services			-0.05**	0.04		
			(0.03)	(0.14)		
dummy for livestock loss/Death			-0.19***	0.22		
			(0.06)	(0.33)		
log of modern bed					0.07***	-0.14
					(0.02)	(0.09)
ownership of fridge					0.05	-0.16
					(0.03)	(0.19)
log no tables and other assets					-0.002	-0.01
					(0.01)	(0.07)
ownership of Sofa					-0.01	-0.25*
					(0.03)	(0.15)
dummy for loss of job					-0.04	0.71
					(0.09)	(0.50)
access to remittances					0.07*	0.10
					(0.04)	(0.20)
Constant	8.62***	-1.81***	9.00***	-2.07***	8.58***	-2.57***
	(0.08)	(0.42)	(0.12)	(0.63)	(0.11)	(0.61)
R -squared	0.62	0.13	0.54	0.44	0.56	0.11
No of observations	4640	4640	1957	1957	2683	2683
F(26, 4613) =	293.54	8.37	79.77	54.33	118.29	11.04
Prob > F	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: all variables in logs except shares and binaries, standard errors are in parenthesis and significant at * p<0.1; ** p<0.05; *** p<0.01

Analysis of Equilibrium Relationship among Government Budget Deficit, Money Supply and Inflation in Ethiopia: Co-integrated VAR Analysis Approach

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Abstract

This study attempted to provide empirical evidences for causal long-term relationship between budget deficit, broad money supply and inflation in Ethiopia. For this purpose, the study employed co-integrated VAR or vector error correction (VEC) model approach by using annual time series data over 1975-2012. The study also investigated direction of causality by using Granger causality test. Parameters of the system were estimated by using Johansen estimation approach. The results show that positive causal relationship between money supply and inflation both in the short and long run. It also shows that budget deficit affects both money supply and inflation in the long run. However, this is not conclusive by taking into account granger causality test. But both money supply and inflation do not Granger cause government budget deficit.

Key words: Budget Deficit, Money Supply, Inflation, Hypothesis testing.
JEL Classification: H62, E51, E31, C12

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1. Introduction

The objectives of monetary and fiscal policies are either economic growth or macroeconomic stability or both. Although, the concern of policy-makers in developing countries like Ethiopia is to attain rapid growth and structural change, inflation takes a remarkable place in development process of a given *economy* (Hossain and Chowdhury, 1996). Inflation is persistence and appreciable rise in the general price level in the economy. The rise in general price level may be attributable to expansionary monetary policy and persistent fiscal imbalances. Thus it can be argued that the objectives of a stable price level, the optimal level of government budget deficit and monetary balance are intertwined and needs to be considered jointly.

The relationship between budget deficit, money growth and inflation has acquired a prominent place in macroeconomic economic literature overtime. The two traditional approaches which have been used to explain the link between these macroeconomic variables are monetarist hypothesis (MH) and the fiscal theory of the price level (FTPL). Another alternative theory, based on dynamic general macroeconomic models with imperfect competition is the new Keynesian (NK) theory. According to monetarist view "inflation is always and everywhere a monetary phenomenon'' and hence, it helps to explain the dynamics of inflation. But, according to FTPL, "price is the result of fiscal activities".

Sustained increase in money growth ultimately translated into increased inflation in the long run when all adjustments have been taken place (Dornbusch and Fisher, 1992). But this still leaves the question of what determines the money supply growth in the economy. A frequent argument says money supply growth is a consequence of government budget deficits. Monetization of budget deficit leads to increase in money supply and hence, produces inflation and macroeconomic instability. As Lozano (2008) stated, high inflation in developing countries emerges a fiscal driven monetary phenomenon. This occurs when the governments finance large and persistent budget deficits through money creation. On other hand, high inflation puts pressure on government budget and leads to high fiscal imbalance (Dornbusch and Fisher, 1994). When the economy experiences high inflation real revenue collected from taxation would fall while government expenditure adjusts to inflation quickly and hence, leads to fiscal imbalance. Another channel through inflation affects budget deficit is increasing nominal interest payment made by the government on national debt.

Extensive number of papers have empirically investigated and evaluated the relationship between money supply, budget deficit and inflation in different countries and ended with mixed results. Significant number of empirical studies show that the existence of significant relationship between money supplies, budget deficit and inflation (Ignacio, 2008; Kanhaya and Gupta, 1992; Olalere, 2012; Mathias, 2015; Parida, 2000; Anwar, 2012). Contrary to this, some other studies found insignificant relationship between inflation and budget deficit (Vincent *et al.* 2012; Tahir and Muhammad, 2010; Hoang, 2014).

For Ethiopia, a remarkable number of papers have investigated the relationship between money supply and inflation. Using VECM, Jema and Fekadu (2012) examined the determinants of food price. Their result revealed that positive impact of money expansion on food price. Dick and Bo (2012) evaluated the driving forces of inflation through single equation error correction model and identified money expansion as short to medium term factor of inflation. Contrary to these, Josef et al (2009) estimated single equation error correction model of inflation and identified insignificant long run relationship between monetary expansion and inflation. Loening *et al.* (2008) examined short-run dynamics of inflation in Ethiopia by using a parsimonious error correction model and found significant short run impact of money supply on inflation. However, there is no studies explicitly cited fiscal deficit as a long run cause of money supply growth and inflation in Ethiopia. None of previous empirical studies also used co-integrated VAR model approach to investigate the dynamic long run relationship among money supply, budget deficit and inflation in Ethiopia. Therefore, this paper attempts to provide empirical evidence on the dynamic long run relationship among monetary expansion, budget deficit and inflation in Ethiopia by using vector error correction model (VECM). The result of this study is relevant for policy makers in Ethiopia, particularly when the government wants to set long run and short run macroeconomic stability. By providing the direction of causal relationship among these variables, it helps the government to effectively implement fiscal and monetary policies and hence to control inflation.

The paper is organized as follows: The next section contains brief review of related theoretical and empirical literature. Section 3 presents descriptive analysis of data trend while Section 4 outlines the methodological approach. Section 5 carries out the empirical analysis and the last section concludes the paper.

2. Review of Related Literatures

2.1 Theoretical Literature Review

The issue of fiscal policy and persistent fiscal imbalances in the economy is controversial and debating issue among different scholars. On the one hand, some argue that budget deficits do not matter but On the other hand, many others have been overly concerned about the existence of huge and persistent fiscal imbalances in many countries (Siamack, 1999).

Some researchers (Auerbach *et al.*, 1991) have attempted to provide measure and computational methodology of budget deficit based on the intergenerational distribution of the burden of financing government budget deficits. According to this approach, members of each generation receive payments and make contributions to the government budget at different times. The generational accounting system computes the net present value of these cash flows based on a given fiscal policy regime. Changes in the fiscal policy that alter the current budget deficit will affect the intergenerational fiscal burden (Siamack, 1999).

Budget deficit affects the supply of money in the economy. The determination of which components of money supply are to be included in the measurement of money supply is related to the level of financial liberalization, or sophistication in a country (Mishkin, 2004). As an economy advances, there evolves an increasing range of monetary and other financial instruments and it becomes increasingly difficult to establish a distinction between them. Recall that a main purpose for measuring the money supply is to facilitate analysis of its growth relative to other macroeconomic targets including inflation and economic growth. In Ethiopia broad money (M2) is used as a measurement of money supply and in this research the analysis will be based on it.

Another important concept which should be concerned in the monetary and fiscal policy analysis is inflation. In economics, the term inflation is usually used to indicate a rise in the general level of prices of goods and services in an economy over a period of time. It has impact on the well being of the economy, macroeconomic stability, standard of living, fiscal and current account balance and etc.

Monetarist hypothesis of money supply-inflation relationship

There are many potential factors that can significantly affect inflation in a given economy. However, when one thinks over the long period of time, monetary economists just focus only on one factor, growth of money supply. The reason for this is that there are no other factors likely to lead to persistent increase in the price level (Romer, 1996). Persistent increase in price level requires persistent fall in aggregate supply or persistent increase in aggregate demand. But these are unlikely and most of the factors are limited in their scope given technology. The money supply, in contrast, can grow at almost any rate; there may be huge variation in money supply during deflations and hyperinflations. Higher growth rate of money causes prices to increase, because higher money growth lowers the value of money or it deteriorates the purchasing power of currency.

In examining the link between money growth and inflation, it is convenient to use monetarist quantity theory of money (Dornbush and Fischer, 1992). That relation between money supply growth and increase in price level is historically associated with the quantity theory of money. The quantity theory relates the level of nominal income (PY), where P is prices and Y is outputs, with the total amount of money stock in the economy (M) and transaction velocity of money (V). As monetarists assume that V and Y are determined, in the long run, by real variables, such as the productive capacity of the economy, there is a direct relationship between the growth of the money supply and inflation. In its modern form, the quantity theory of money builds upon the following definitional relationship.

$$MV = \sum_{i} (P_i Y_i) \tag{1}$$

Where,

P_i *and* Y_i are the price and quantity of the i^{th} transaction. However, the above formula associated with the difficulty of calculation because there is no data available for each transaction in the economy. Due to this, economists work with the more simplified form of the equation based on final product transaction. The simplified model can be expressed as:

$$MV = PY \tag{2}$$

This can also be written in terms of natural logarithm and percentage changes over time for the variables.

$$lnM + lnV = \ln P + \ln Y \tag{3}$$

$$m + v = \pi + y \tag{4}$$

Where, m is money supply growth, v is percentage change in velocity of money, π is the inflation rate and y is the growth rate of output. According to monetarist proposition inflation is predominantly a monetary phenomenon implies that changes in velocities are small and they assume output at its natural level. From quantity theory of money one can infer that there is proportionality between money growth and inflation rate. So, there is clear and strong connection between money stock and price growth.

According to quantity theory hypothesis changes in the money supply have no long run real effects. By considering equilibrium condition for the money market in which equality holds between money supply and money demand and by adding two more assumptions such as national output fixed at equilibrium and money stock is not affected by nominal income we can note that the raise in money supply leads to increase in price level to maintain new equilibrium level (Levačić and Rebmann, 1982). Given that the equilibrium value of output (Y) and velocity of money (V) are fixed, the only way equilibrium can be restored is raise in price level. Here the crucial assumption is that price is assumed to be flexible and adjusts the equilibrium if imbalances occurred in the economy. The models here obey what is known as the “classical dichotomy”- they will have the property that real variables are determined by other real variables, and not by nominal variables. Most of economists believe that the classical dichotomy holds in the long run.

Thus, the quantity theory of money states that the central bank has ultimate control over the rate of inflation by manipulating money supply. If the central bank keeps the money supply stable, the price level will be stable. If the central bank increases the money supply rapidly, the price level will rise rapidly. Hence according to monetarist view Inflation is always and everywhere a monetary phenomenon. Monetary policy has no effect on real variables in the long run but it only affects nominal variables such as price level in the economy.

However, according to Keynesian view monetary expansion affects both real output and inflation in the short run but in the long run they agree with the classical economists (Snowdon and Vane, 2005). A further assumption Keynes introduced is that the theory of liquidity preference, the possibility that the demand for money function might shift about unpredictably, causing velocity of money to vary, implies that changes in Money supply may be offset by changes in velocity in the opposite direction. With output and velocity no longer assumed to be constant in the equation of quantity of money. it is clear that changes in the quantity of money may cause velocity (V), price (P) or output (Y) to vary. According to this view the neutrality of money is no longer guaranteed in the short run.

Fiscal theory of the price level

The fiscal theory of the price level is the idea that fiscal factors replace the money supply as the key determinant of the price level. Stable price level requires sustainable government finances meaning that they must run a balanced budget over the course of the business cycle. It is a contrary to widely accepted economic theories of the price level, which states that the price level is primarily or exclusively determined by the growth of stock of money in the long-run.

Walsh (2010) point out that fiscal theory of the price level raises some important issues for both monetary theory and monetary policy. There are two ways fiscal policy might matter for the price level. First, equilibrium requires that the real quantity of money equal the real demand for money. If fiscal variables affect the real demand for money, the equilibrium price level will also depend on fiscal factors. This, however, is not the channel emphasized in fiscal theories of the price level. Instead, these theories focus on a second aspect of monetary models - there may be multiple price levels consistent with a given nominal quantity of money and equality between money supply and money demand. Fiscal policy may then determine one of these equilibrium price levels and in some cases, the equilibrium price level picked out by fiscal factors may be independent of the nominal supply of money.

In contrast to the standard monetary theories of the price level, the fiscal theory assumes that the government's intertemporal budget equation represents an equilibrium condition rather than a constraint that must hold for all price levels. A price level at which intertemporal government budget constraint hold is consistent with equilibrium. Given the stock of nominal debt, the equilibrium price level must ensure that the government's intertemporal budget is balanced (Walsh. 2010). The fiscal theory of the price level implies that a government could exogenously fix its real spending, revenue and seigniorage plans, and that the general price level would adjust the real value of its contractual nominal debt obligations so as to ensure government solvency (Buite, 1999).

This means that at price levels not equal to equilibrium price, the government is planning to run surpluses/deficit (including seigniorage) whose real value, in present discounted terms, is not equal to the government's outstanding real liabilities. Similarly, it means that the government could cut current taxes, leaving current and future government expenditures and seigniorage unchanged, and not simultaneously plans to raise future taxes. If prices are deviated from its equilibrium level the government run deficit or surplus.

Developing countries have four different ways to finance their high budget deficit which are printing money, running down foreign exchange reserves, borrowing from abroad and domestic markets (Sahan and Bektasoglu. 2008). Inflation has raising effect on budget deficit through nominal interest rate. According to Fischer Effect; nominal interest rate consist of real interest rate and expected inflation rate. If the inflation expectation increases, it causes to rising nominal interest rate which leads to the public debt to go up, since interest payment covers the big part of public payment in developing countries. If interest rate increases because of inflation, it leads to raise interest payment as well as budget deficit by causing the Debt/ GDP ratio to go up. Thus, high interest rate and interest payment lead to instability between budget and public deficit acceleration and tax revenue acceleration. Public expenditure always increases faster than public revenue so as budget deficit increase as well.

The reverse effect of budget deficit on inflation is analyzed by using government intertemporal budget constraint. The intertemporal budget constraint implies that any government with a current outstanding debt must run in present value terms, of future surpluses. One way to generate a surplus is to increase revenues from seigniorage, and for that reason, economists have been interested in the implications of budget deficits for future money growth.

However, (Bektasoglu and Sahan.2008) stated that in spite of the positive relationship between inflation and budget deficit, in some cases inflation and budget deficit move in reverse direction. If inflation tax is higher than normal level, as inflation increase people avoid holding money because the cost of holding money is high. Thus, real monetary base tends to decrease as inflation tax correspondingly. Holding money would be a costly activity. Inflation tax would be a type of tax revenue which makes the budget deficit decline. If borrowing is not indexed to the inflation, as the inflation rise the real value of public borrowing stocks would decline. As the public borrowing stock fall, budget deficit is expected to decrease.

Therefore, monetary expansion, fiscal deficit and inflation in a given economy are interlinked. Budget deficit affects money supply, money supply affects inflation and inflation in turn affects fiscal imbalances. There is vicious circle like relationship between these macroeconomic variables.

2.2 Empirical Literature Review

Extensive number of papers have empirically investigated and evaluated the relationship between money supply, budget deficit and inflation with mixed results. Some of them found no significant relationship among these macroeconomic variables and the results of several others papers are on the contrary.

Using post-1999 period data from Brazil, Chile, Colombia and Mexico Luiz (2008) estimated simultaneously a monetary reaction function and the determinants of expected inflation by using VEC model. The revealed result shows the existence of long term relationship among the interest rate, expected inflation and inflation target, which suggests that the importance of monetary policy in tackling inflation. The finding of the same study also showed that greater volatility in the monetary stance leads to higher volatility in expected inflation.

Ignacio (2008) examined the causal long term relationship between budget deficit, money supply and inflation in Colombian by using VEC model. He used two sets of data, quarterly data over the period of 1982Q1 to 2007Q4 and annual data from 1955 to 2007. In the first case the study has found close relationship between inflation and money supply one hand and between budget deficit and money growth on the other. But, in the second case the study didn't find significant relationship between budget deficit and money growth.

Using Nigerian data over the period of (2000Q1-2013Q4), Mathias (2015) evaluated the relationship between money supply, inflation, interest rate and exchange rate by employing recursive vector auto regression (VAR) model. The result of the study revealed that inflation in Nigeria is monetary phenomena. Using annual data from 1980-2009 Abel and Olalere (2012) examined the relationship between budget deficit and inflation in the same country by employing VEC model mechanism and found causal long term relationship among them. As they stated budget deficit transmitted to inflation through money supply growth. Ibrahim et al (2014) investigated the long run relationship between money supply, budget deficit (percentage of GDP), inflation and growth of external debt/GDP in Nigeria over the period of 1975 and 2012. Through error correction model (ECM) of single equation the study provided support for the existence of long run relationship between inflation, money supply and budget deficit. Using data over 1970-2006 similar study (Vincent et al. 2012) revealed insignificant relationship between inflation and budget deficit on one hand and significant positive relationship between money growth and inflation on the other hand.

For Pakistan, using quarterly observations over the period 1960-2007 and applying Johansen co-integration approach Tahir and Muhammad (2010) examined the long run relationship between money supply, budget deficit and inflation. The result provided that the impact of fiscal deficit on inflation is not significant and contrary to this money supply significantly affects inflation in the long run.

Among empirical studies with mixed results, Petraq (2012) evaluated the relationship between budget deficit, money supply and inflation in three transition economies of Albania, Bulgaria, and Romania over first quarter of 1991 to last quarter of 1997. Through OLS method, he found that public finance imbalance is the main cause of money creation and inflation in these countries. Kivilcim (2011) examined the relationship between Inflation and Budget Deficit in Turkey over 1950-1987 annual observation. Using multivariate cointegration analysis technique of single equation he found budget deficit, income growth and debit monetization have affected inflation. Using Tanzanian data over 2000 to 2011 and examining through OLS, ECM and VAR mechanism, James *et al*., (2014) found similar result. VECM result estimated from Iranian quarterly data over 1988Q1 to 2005Q4 indicated, inflation in the long run induced by monetary expansion but this result is not holds in the short run (Mehdi and Seyyed. 2013). Using Vietnam's monthly data set from January 1995 to December 2012 Hoang (2014) examined the relationship between budget deficit, money supply and inflation through Structural VAR model. The result of the study found positive impact of money growth on inflation while, budget deficit has no impact on both money growth and inflation.

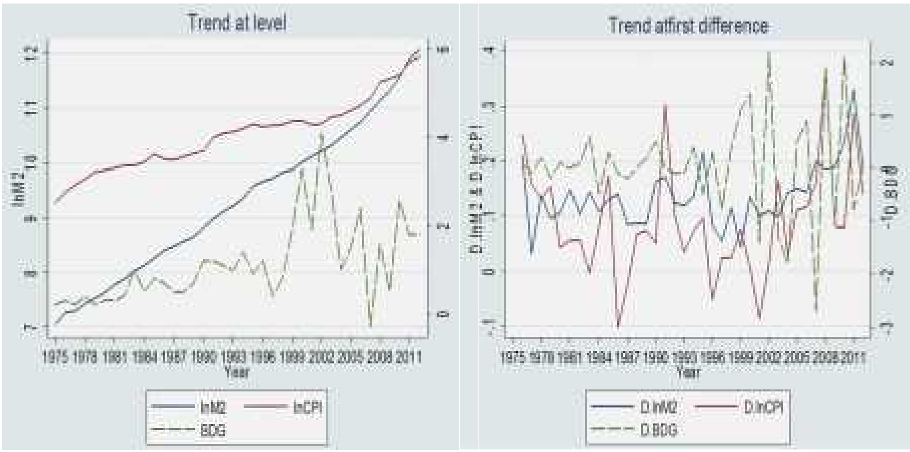
Gupta (1992) analyzed the effects of budget deficit on money supply growth by using reduced form equation models for selected Asian countries by using annual data. The results of his estimation shows that budget deficits do not have a strong influence on the growth of money supply. He also examined the effect of budget deficit on inflation by using annual data through structural and non-structural approaches. Based on structural approach employing error-correction model, budget deficits seem to exercise direct effects on inflation in Malaysia, Pakistan, the Philippines, Sri Lanka, Taiwan, and Thailand. But there is no evidence of such direct effects in India, Indonesia, South Korea, and Singapore. The indirect effects of budget deficits on inflation exist in India, Indonesia, Malaysia, the Philippines, Singapore, Sri Lanka, Taiwan, and Thailand. The result from non-structural approach has also supported strong causal relationship between budget deficit and inflation.

With reference to Ethiopia, there are remarkable number of papers assessing the relationship between inflation and its determinants. Using quarterly data over (1996/97 Q1– 200/08Q3), Kibrom (2008) empirically identified the determinants of inflation in Ethiopia. Through vector autoregressive (VAR) and single equation error correction model, he has found positive and significant relationship between inflation and money supply in the long run. Yemane (2008), examined the causal link among inflation, money and budget deficits in Ethiopia over (1964 - 2003) by using the bounds test approach to co-integration and Granger causality test. The result shows that money supply Granger causes inflation and also budget deficits Granger causes inflation. Contrary to this, Asayehgn (2008) evaluated contributing factors of inflation in Ethiopia over (1991M2-2006M7) through OLS method and found positive but insignificant relationship between money supply and inflation and between budget deficit and inflation. There are no previous studies that empirically evaluate the long run relationship between budget deficit, money growth and inflation by using vector error correction model (VECM), as proposed in this paper.

3. Descriptive Analysis

As a preliminary to the econometric analysis, descriptive analysis of data trend is discussed in this section. The variables are broad money supply (M2), general consumer price index (CPI) and percentage share of budget deficit to GDP ratio (BDG). Both M2 and CPI are in natural logarithm form and BDG is in positive number because it is a form of percentage share from 1975 to 2012. From Figure 1, one can notice that upward trending of each variable at level but at first difference they become stable. The graphs also displays that the variables involved in the system have common stochastic trends. In other words, they have common tendency to move together over time.

Figure.1: Trends of broad money supply. CPI and BDG from 1975 to 2012



Budget deficit to GDP ratio has shown some fluctuations over the sample period. Different factors may be contributed to these. For example, increase in defense expenditure from 3.5% of GDP in 1997 to 10.2% of GDP in 1999 and hence, contributed to the increase of federal government expenditure from 19.6% to 26.3% as percentage of GDP over the same period, while, revenue decreased from 17.2% to 17% as percentage of GDP over these periods. Since, 2000 the government highly increased its expenditure (road construction (from 1.9% in 2000 to 5.2% in 2012), education (from 0.9% to 2.5%), agriculture (from 0.9% to 1.4%) and natural resource (from 0.5% to 1.7%)) as a percentage of GDP from 2000 to 2012. But revenue to GDP has not been shown significant change over these periods. The government deficit has been financed from domestic banking system over 1975 to 1993 and 1999. This has further influenced money supply and hence inflation in Ethiopia during the sample period.

Even though. Ethiopian economy has achieved high economic growth (average rate of 10.4%) compared to Sub-Saharan Africa average of 5.3% from 2004 to 2014 (IMF Regional Economic Outlook. 2015). inflation was remaining its great challenges over these periods (JOSEF *et al*., 2009). However, the government claimed that inflation has been maintained at single digit by taking robust monetary and fiscal policies (MoFED, 2013). Different authors outlined different reasons for the existence of high inflation in Ethiopia as discussed in introduction section. But, Figure 1 shows that natural log of CPI moves with natural log of broad money supply and budget deficit to GDP ratio. From this one can understand that money supply and budget deficit are possible cause of inflation in Ethiopia. Therefore, the objective of this study is empirically investigating causal long term relationship among M2, CPI and BDG in Ethiopian by using VECM.

4. Econometric Methodology and the Data

4.1 Methodology

As Lütkepohl and Kr¨atzig (2004) stated, including many variables in the single equation may not capture the dynamic, inter-temporal relationship among the variables and may not lead to better result. In this case, formulating the interrelations among economic variables as a system provides sufficient information about the variables (Anindya *et al*. 2003). Vector autoregressive (VAR) process based on Gaussian errors is a robust and suitable model class for describing dynamics of macroeconomic time series data. Other reasons for the frequent choice of VAR model are: Its flexibility, easiness to estimate, and its good fit to macroeconomic data. It also used for structural inference, forecasting and policy analysis. The possibility of combining long-run and short-run information in the data by exploiting the co-integration property is probably another important reason why the VAR model continues to receive the interest of both econometricians and applied economists. Making inference based on VAR formulation is consistent than making inference based on isolated single equation (Juselius, 2006).

Despite these, VAR model has its own limitations, for example, it does not based on standard set theories and may produce different result from theory based models. Restrictions are usually imposed with statistical techniques instead of prior beliefs based on uncertain theoretical considerations (Lütkepohl and Kr¨atzig. 2004). However, if it is empirically well defined, it produces robust result which better fits macroeconomic data and hence addresses the limitation of theory based models. Theory based models are over simplified by the assumption of ceteris paribus and may explain little about the real economic situations. In this case VAR model is useful to develop new hypothesis or to modify the very narrow theories (Johansen, 1995; Juselius, 2006 and Watson, 1994). But, VAR produces valid estimate/forecasts only when covariance stationarity or no unit root assumptions are fulfilled. Another shortcoming of VAR model is that it fails to spilt short term causality and long term relationships among economic variables.

When we are thinking about long run relationship among variables, it is necessary to consider the underling properties of data generating process i.e. series stationarity and co-integration relations. Since failure to do so can lead to a problem of spurious regression meaning that invalid inference (Harris. 1995). These are the task testing order of integration and order of co-integration. VAR model produces valid result when the underlying data generating process is covariance stationary and the order of co-integration is zero. But most of economic time series variables don't exhibit stationarity at their level and they may show common tendency to move together for some extent. Hence it is necessary to have models that accommodate these features of data generating process. One possible technique is performing VAR analysis after differencing integrated individual components involved in the system if it doesn't distorts important features of variables. But, this may be inadequate in deriving inferences and forecasting (Lütkepohl, 2005*)*. Another robust and more appropriate technique is to analyze data within a co-integration framework.

Co-integration refers to equilibrium relationship which characterized by having common stochastic trend among a set of variables. It naturally arises in economic variables and most often associated with economic theories that imply equilibrium relationship among the variables. The appropriate model which accommodates these issues is known as vector error correction models (VECM) or co-integrated VAR (CVAR) model or vector equilibrium correction model (Lütkepohl & Kr¨atzig, 2004) which has extensively used in modeling economic equilibrium relationship (Hubrich, 2005). This methodology is a growing approach in econometrics application of analyzing the dynamic long run equilibrium relationship and short term causality among integrated variables and has been playing an explicit role in econometric modeling of economic time series data. Juselius (2006) described several advantages of VECM formulation among others: first, the autocorrelation and multicollinearity problem which typically arises in time-series data would be significantly reduced in the error-correction form. Second, all information about long-run effects are summarized in the levels matrix (subsequently denoted by m). Third, the interpretation of the estimates is more intuitive, as the coefficients can be naturally classified into short-run and long-run effects. Fourth, the VECM formulation gives a direct answer to the question ‘why a given variable changes from time to time as a result of changes in the chosen information set.

VEC model which captures both long run dynamic relationship and short run causality among macroeconomic variables can be specified in the form of:

$$\Delta Y_t = \text{m}Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_{p-1} \Delta Y_{t-p+1} + \mu + U_t \qquad [5]$$

Where, rank of $(\text{r}\Pi) = \text{r}$ with $0 < r < K$. then reduced rank matrix $\mathbf{\Pi}$ is not unique can be decomposed as $\text{m} = \boldsymbol{\alpha}\boldsymbol{\beta}'$. The parameters α and β are (kxr) matrices with $\text{rk}(\boldsymbol{\alpha}) = \text{rk}(\beta) = r$; where, k indicates number of variables in the system; α is adjustment coefficient; and β represents long run coefficients of the model which is called co-integrating vector. The short run components of the model is captured by $\text{d}_j(j = 1, \ldots p-1)$ which are $(K \times K)$ parameter matrices. The error term component of the model is assumed to be

Gaussian white noise i.e. $u_t \sim (0, \Sigma u)$ while Y_{t-1} contains I(1) variables. Due to its clear separation between the long-run parameter (β) and the short-run effects (d_j) VECM formulation has becomes attractable.

The co-integration hypothesis can be formulated as a reduced rank restriction on the **Π** matrix. The choice; 2 of α and β. in addition to reproducing the **Π** matrix, should ideally describe an interpretable economic structure and provide empirical insight on the appropriateness of the underlying economic model (Juselius, 2006). The co-integrating rank *r shows* the number of linearly independent co-integrating relation of the system. In other words r measures the number of stationary linearly independent relations available in the system. Johansen methodology is commonly applied to test the existence long run relationship (co-integration relations) among the variables.

Moreover, the VECM specification is not particularly useful in the cases of zero co-integrating vector and full rank co-integrating vector. The former indicates the absence of co-integrating relationship among the variables, while the later shows all variables involved in the system are stationary. In both case VAR model with first-differenced variables and at level can be used to analyze the relationship among the variables in the system (Lütkepohl and Krätzig, 2004 and Lütkepohl, 2005). Nonetheless, a unit root is often a convenient statistical approximation, which enables us to utilize a much richer framework (VECM) that distinguishes between the longer and shorter term dynamic effects. It is therefore useful to consider unit roots for the empirical analysis of macroeconomic relationships since neglecting it invalidate our analysis. Among the test procedures Augmented Dickey Fuller (ADF) test procedures will be applied to determine the order of integration (existence of unit root) in the endogenous variables such as budget deficit, money supply and CPI.

The most usual estimation method for the VECM presented above is the maximum likelihood estimator (MLE) proposed by Johansen (1995), which uses the reduced rank regression (RRR). In Johansen's approach, the parameter estimator is made unique by normalizing eigenvectors, and adjusting accordingly (Lütkepohl and Krätzig, 2004). Therefore, appropriate identification restrictions needed to be imposed on co-integrating vector but we should be careful with the order of the variables and our interpretation.

Another important point must be considered before fitting unrestricted model with *p* lags is checking whether the underlying assumptions of the model are satisfied or not, otherwise the procedures derived may not be valid (Johansen. 1995). In particular it is important to determine the optimal lag length, check absence of autocorrelation problem, Gaussian white noise process.

The optimal lag length for the VAR or VEC model can be determined by using information criteria procedures such as Akaike's Information Criterion (AIC), final prediction error (FPE), Hannan-Quinn criterion (HQ), and Schwarz criterion (SC). The strategy for determining the optimal lag length is choosing the lag that minimizes the information criterion. An important criterion for the choice of lag length is that the residuals are uncorrelated. To test residual autocorrelations Portmanteau test and Lagrange multiplier test can be used. However, it is important to avoid too many lags (Johansen, 1995). Once the lag length of VAR model determined it is straightforward to determine the lag length of VECM. In addition to these, structural analysis: granger causality test and impulse response analysis and structural change i.e. VECM parameter stability test would be carried out as tool for diagnostic checking to validate VEC model results and supplement long run analysis (Lütkepohl, 2005).

4.2 Data

This study is based on annual fiscal and monetary data from 1975 to 2012. The variables are percentage of budget deficit to GDP ratio (BDG), broad money supply (M2) and consumer price index (CPI) as endogenous variables. BDG is calculated by subtracting government revenue from government cost and take it as percentage of GDP and hence it is positive number. Broad money supply (M2) contains money at circulation, demand deposits, savings deposits and time deposits. Budget deficit and GDP are obtained from MoFED while money supply and consumer price index are obtained from National Bank. Even though, it is recommended to use time series data from the same source, the reason why the author relies on two data sources is that lack of long term data on all variables from one source. Due to the lack of long term quarterly data, the researcher forced to use annual data.

5. Econometrics Results and Discussion

5.1 Properties of the System

Augmented Dickey-Fuller test (ADF) procedure is commonly applied in determining unit root properties of economic time series data. The results of ADF tests both at level and first difference for each series are presented in Table 1. Test results, indicate that all variables are integrated of order one i.e. $I(1)$ at 5 percent level. In other words, non-stationarity hypothesis can be rejected at first difference of the series.

According to AIC and FPE tests, chosen lag length for the VAR model is two (Table 2). Because for small sample size time series AIC and FPE are preferable than SC and HQ criterion (Lüptkepohl, 2005). The order of VEC model automatically set one less than the order of VAR model.

Table 1: ADF (2) Unit root test

Variables	Test statistics		Critical value		
	At level	At first difference	1%	5%	10%
[illegible]	1.6099	-3.2137			
[illegible]	0.3512	-3.9988	-3.43	-2.86	-2.57
[illegible]	-1.8191	-6.4025			

Table 2: VAR model lag order selection criterion

Lag	FPE	AIC	SC	HQ
0	.018311	4.51331	4.55908	4.64935
1	.000015	-2.79689	-2.61378**	-2.2527**
2	.000012**	-2.92371**	-2.30328	-1.67138
3	.000023	-2.20815	-1.7504	-.847692
4	.000019	-2.49169	-1.89661	-.723087

****** Shows VAR Order which minimizes information criteria

Table 3 presents the results of the Lagrange Multiplier (LM) test which was proposed by Breusch (1978) and Godfrey (1978) and LMF test (with standard F-approximation) tests for VAR model residual serial autocorrelation. According to these tests we fail to reject the null hypothesis of absence of systematic serial autocorrelation up to lag two even at 10% level.

Table 3: Test for residual autocorrelation up to lag two (LM-type test)

Lags	LM-Stat		LMF-Stat	
	Statistic	p-value	Statistic	p-value
1	8.4019	0.9720	0.7495	0.6840
2	9.0500	0.43268	1.1820	0.3573

Table 4: Test for normality

Equation	Jarque-Bera test		Skewness test		Kurtosis test	
	chi2	Prob > chi2	chi2	Prob > chi2	chi2	Prob > chi2
lnM2	0.498	0.77941	0.386	0.53443	0.112	0.73735
[illegible]	0.055	0.97275	0.004	0.95137	0.052	0.82043
BDG	6.826	0.03294	1.541	0.21449	5.286	0.02150
Joint	7.380	0.28712	1.931	0.58694	5.450	0.14169

Table 5: Johansen co-integration test

Maximum Cointegrating Vector	Eigenvalue	λ_{trace}	5% critical Value	λ_{Max}	5% critical Value	P-value of S&L test
r = 0	0.50228	114.3554	34.91	88.3910	22.00	0.0015
r ≤ 1	0.90827	25.9644	19.96	22.5901	15.67	0.0650
r ≤ 2	0.45694	3.3743**	9.42	3.3743**	9.24	0.5045*

** indicates acceptance of null hypothesis at 5% significant level

Normality test based on multivariate version of Jarque Bera tests, skewness test and excess kurtosis test are presented in Table 4. The results shows that the null hypothesis of normality cannot be rejected for M2 and CPI at 5% level while, for BDG we can accept normality assumption only at 1%. In the presence of outlier in the model, failure of Jarque-Bera test is a common phenomenon, which will not crucially distort final results. But they are jointly normally distributed based on all tests.

Johansen (1995) lambda trace and lambda maximum, Eigen value. and Saikkonen and Lütkepohl (S&L) co-integration tests procedures are applied to determine the number of co-integrating vector. S&L and Johansen test proceeding sequentially from the first hypothesis of zero co-integrating vectors to an increasing number of co-integrating vectors. The results of $\lambda_{trace,}$ λ_{Max} and S&L Co-integration test statistics are reported in Table 5. All test statistics indicate that the existence of two co-integrating vector (r=2) in the system at 95 percent confidence level.

5.2 Vector Error Correction (VEC) Model Specification and Results

In VECM we assume that changes in variables at period t depends on deviations from equilibrium relationship at period t-1. Moreover, the model assumes that changes in the variablk2es at time t depends not only on deviations from the equilibrium relationship, but also on changes in each of the variables at period t-1.

Since two co-integrating relations are present among money supply, consumer price index and budget deficit to GDP ratio, vector error correction models (VECM) allows us to incorporate the co-integration structure in the model. The VEC model is useful to establish equilibrium relationship among a set of economic variables under consideration. In addition, when there is short term deviation from the long run equilibrium path, the model is also helpful to evaluate the dynamic adjustment towards its equilibrium in the system. The model can be specified as:

$$\Delta Y_t = \boldsymbol{\Pi} \mathbf{Y}_{t-1} + \Gamma_1 \Delta Y_{t-1} + \mu + U_t \qquad \textbf{[6]}$$

Where, $\Delta Y_t = [\Delta \ln M2_t \;\; \Delta \ln CPI_t \; \Delta BDG_t]'$; $U_t = [u_{1t} \; u_{2t} \; u_{3t}]'$; μ = con; $\boldsymbol{\Pi}$ is the long term parameter and Γ_1 is short term parameter of (3x3) matrix. The long run equilibrium relationship between the variables could be given by:

$$\Pi Y_{t-1} = \alpha\beta' Y_{t-1} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{bmatrix} \begin{bmatrix} \ln M2_{t-1} \\ \ln CPI_{t-1} \\ BDG_{t-1} \end{bmatrix}$$

Where, α is vector of adjustment parameters and β is cointegrating vector, if $\alpha \neq 0$. the co-integrating equation $\beta' Y_t$ is stable and. Thus, represents a co-integration relation. To uniquely estimate co-integrating parameters Johansen normalization methodology of identification would be applied.

The matrix α is adjustment parameter which is sometimes called the loading matrix and it contains the weights attached to the co-integrating relations in the individual equations of the model. In other words it measures the speed of adjustment of the variable towards its long run equilibrium in response to short term deviations. It has an important implication in equilibrium analysis. If all α coefficients are zero in the equation of a particular variable, that variable is considered as weakly exogenous to the system and hence, doesn't enter in to co-integrating relations. But, β matrix contains the co-integrating relations or linear transformations of them. For a particular period, the long–term relationship could be expressed as $\beta' Y_{t-1} = \varepsilon_t$ where ε_t is white noise process which represents short term deviations from the equilibrium level. If the equilibrium relationship actually exists, it is reasonable to assume that Y_t variables move together over time and ε_t is stable. Given two co-integrating relations in the system, the long term relationships among money supply ($lnM2$), consumer price index ($lnCPI$) and government budget deficit to GDP ratio (BDG) can be specified as:

$$\begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ \beta_{12} & \beta_{22} & \beta_{32} \end{bmatrix} \begin{bmatrix} lnM2_t \\ lnCPI_t \\ BDG_t \end{bmatrix} = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

Without further restriction on co-integrating vectors the long run parameters cannot be identified (Lütkepohl, 2005; Lütkepohl and Kr¨atzig, 2004; Juselius, 2006 and Johansen, 1995). In practice, the estimation of the parameters of a VECM requires at least r^2 identification restrictions. Since we have two co-integrating vector conventional Johansen restriction methodology require four identification restrictions to be imposed. After normalizing on money supply and consumer price index the long run equations can be expressed as:

$$\begin{bmatrix} 1 & 0 & \beta_{31} \\ 0 & 1 & \beta_{32} \end{bmatrix} \begin{bmatrix} \ln M2_t \\ \ln CPI_t \\ BDG_t \end{bmatrix} = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \qquad \textbf{[7]}$$

From this the long term equilibrium relationship between money supply and government budget deficit and between inflation and government budget deficit can be expressed as follows:

$$\ln M2_t = -\hat{\beta}_{31} BDG_t + \widehat{\varepsilon_{1t}} \qquad \textbf{[8]}$$

$$\ln CPI_t = -\hat{\beta}_{32} BDG_t + \widehat{\varepsilon_{2t}} \qquad [9]$$

Where, $\widehat{\varepsilon_{1t}}$ and $\widehat{\varepsilon_{2t}}$ are stationary disturbance terms and being represents the short term deviations of a particular variable from its long run equilibrium path. If we change the order of variables and impose restriction on consumer price index and budget deficit to GDP ratio the long run equilibrium equation can be expressed as:

$$\ln CPI_t = -\hat{\beta}_{11} \ln M2_t + \widehat{\varepsilon_{1t}} \qquad \textbf{[10]}$$

$$BDG_t = -\hat{\beta}_{12} \ln M2_t + \widehat{\varepsilon_{1t}} \qquad \textbf{[11]}$$

The results of estimated VEC model based on Johansen methodology for natural log of broad money ($lnM2$), natural log of consumer price index ($lnCPI$) and percentage of budget deficit to GDP ratio (BDG) are presented in Table 6 and Table 7 below. In the first case co-integrating vectors are normalized on lnM2 and lnCPI to measure the effect of fiscal deficit on them and hence to obtain their long term equilibrium equations.

Table 6: VECM result: Johansen normalization restrictions imposed on *ln*M2 & *ln*CPI

		Eigenvectors ([illegible])	
	lnM2	**lnCPI**	**BDG (z-value)**
_ec1	1	0	-1.558 (-5.114)
_ec2	0	1	-0.730 (-4.566)
	Standardized Adjustment parameters ([illegible]		
	ΔlnM2 (z-value)	ΔlnCPI (z-value)	ΔBDG (z-value)
[illegible]	-0.090 (-2.443)	0.189 (2.762)	0.864 (1.433)
[illegible]	0.198 (2.975)	-0.325 (-2.612)	-0.849 (-0.776)
	Deterministic term ([illegible]		
	ΔlnM2 (z-value)	ΔlnCPI (z-value)	ΔBDG (z-value)
Constant	0.163 (1.944)	-0.404 [-2.578)	-3.330 [-2.415)
	Short term parameters (Γ'[illegible]		
	ΔlnM2	ΔlnCPI	ΔBDG
[illegible]	0.056	0.735**	-1.758
[illegible]	-0.008	0.132	-1.699
[illegible]	0.006	0.028	-0.160

Table 7: VECM result: Johansen normalization restrictions imposed on *lnCPI* & *BD(*

		Standardized Eigenvectors ([illegible])	
	[illegible]	**BDG**	**lnM2 (t-value)**
_ec1	1	0	-0.619 [-20.224)
_ec2	0	1	-0.426 [-6.695)
	Standardized Adjustment parameters ([illegible]		
	[illegible]	[illegible]	[illegible]
[illegible]	-0.199 [-2.594)	-0.637 (-1.266)	-0.132 [-2.749)
[illegible]	-0.037 [-1.443)	-0.847 [-5.031)	-0.009 [-0.557)
	Deterministic term ([illegible]		
	ΔlnCPI (t-value)	ΔBDG (t-value)	ΔlnM2 (t-value)
Constant	-0.575 [-2.688]	-3.514 [-2.509]	-0.232 [-1.742]

* Indicates statistically significant at 0.1 level & ** Indicates significant at 0.05 level

Adjustment coefficient (α vectors) measures how the variable adjusts towards its equilibrium to correct short term imbalances. In other words, it indicates that whether the variables entered as explanatory variable is weakly exogenous to the system or not and the variable chosen to be explained is endogenous to the system. In the case of first normalization, we fail to reject the weak exogeneity hypothesis for BDG. In other words, there is no feedback effect onto BDG from disequilibrium in both co-integrating relations in the in previous period. But, both money supply growth and inflation are endogenous to the system. This further confirms the existence of at most two co-integration relations in the system. However, in the case of second normalization we fail to accept the weakly exogeneity assumption for all variables.

By normalizing co-integrating vectors on both broad money supply and CPI and taking into account the significance level of long term parameters we can write the long-term equations for $lnM2$ and $lnCPI$ as follows:

$$\widehat{lnM2}_t = 1.56BDG_t + \hat{\varepsilon}_{1t} \quad [12]$$

$$\widehat{lnCPI}_t = 0.730\,BDG_t + \hat{\varepsilon}_{2t} \quad [13]$$

The VECM result shows that in the long run government budget deficit to GDP ratio has positive and significant impact on the growth of broad money supply. The sign of the coefficient on budget deficit is as expected and can be interpreted as a unit increase in percentage of budget deficit to GDP ratio on average leads to 1.56 percent per annum increase in broad money supply in the long run. This result is consistent with theoretical framework and the empirical results obtained from other studies. For example, Ignacio (2008) investigated long run relationship among budget deficit; money growth and inflation by using Colombian quarterly data and has found positive relationship between budget deficit and money supply. Petraq (2012) explored the impact of budget deficit on money supply growth and inflation in three transition economies: Albania, Bulgaria and Romania, and has found positive and significant effect of budget deficit on both variables. But in the short run coefficient of budget deficit in money supply equation is not statistically significant. The fiscal deficit can be financed from domestic and foreign sources. The former includes borrowing from banking and non-banking sectors and direct printing of money. All these have both direct and indirect influences on money supply growth. Government's repayment of both principal and interest on debts in the long run further deteriorates fiscal deficit and hence, increases money supply in the economy. The α coefficients -0.09 and 0.198 shows that feedback effect of co-integrating relations on money supply. In other words, money supply adjusts itself to correct short term imbalances at rate of 9% and 20% per year for the first and second co-integrating relations.

Budget deficit also has positive and significant long run effect on inflation (Table 6 and Equation 8). Its sign is as expected and compatible with fiscal theory of price level and empirical evidences from other countries (see; Musa, 2014; William and Klaus, 2010; Furrukh, *et al.* 2011; Kivilcim, 2011; Petraq, 2012). The coefficient in inflation equation (13) can be interpreted as 1 percent rise in budget deficit to GDP ratio on average leads to 0.75 percent raise in CPI in the long run. The effect of fiscal deficit on inflation is depends on the interaction of budget deficit and GDP growth. In other words, it has no effect on inflation in the long run, if GDP and fiscal imbalances grow at the same rate. But BDG has null effect on inflation in the short run. The standardized adjustment coefficients $(\alpha's)$ on inflation equation show that both co-integrating equations have feedback effect on inflation and hence inflation converges at the rate of 32.5% for the second co-integrating relation and 19% for the first equation.

By reversing the order of variables and imposing Johansen identification restriction on CPI and Budget deficit to GDP ratio we can find long run equations of CPI and BDG as a function of broad money supply. Here our interest is to investigate the impact of broad money supply growth on inflation and government budget deficit to GDP ratio.

The estimated β coefficient (Table 7) shows that money supply growth significantly affects general price level and its sign is as expected. Its value can be interpreted as on average; one percent rise in money supply induces inflation by 0.62 in the long run, holding other factors constant. This result is compatible with monetarist hypothesis and empirical evidences obtained from other countries (Kivilcim, 2011; Petraq, 2012; Furrukh, *et al.* 2011; Ignacio, 2008; Hoang, 2014; Mehdi and Seyyed, 2013; James *et al.* 2014). For example, Furrukh *et al*. (2011) obtained long run broad money supply coefficient of 0.61 in inflation equation by using Pakistan data; and Mehdi and Seyyed (2013) obtained 0.785, coefficient of money supply in the long run inflation equation from Iran data. The standard adjustment parameters (Table 7) show that inflation fairly converges for the deviant nature of money supply from long run equilibrium. Money supply growth has also positive and significant effect on inflation. The magnitude of short run coefficient is 0.735, which is quite greater than that of long run coefficient.

Budget deficit to GDP ratio increases with broad money supply growth in the long run (Table 7). The coefficient of 0.426 on BDG equation has the expected sign which intuitively seems realistic and it is statistically and economically significant. In particular, 1% rises in money supply on average stimulates percentage of budget deficit to GDP ratio to increase by 0.43 in the long run but its effect in the short run is nil. The adjustment parameters (α's) shows that budget deficit is not sensitive for imbalances in the first co-integrating relation but for the second (see Table 7).

5.3 Structural Analysis and Model Checking

Pair wise Granger-Causality

The term Granger-causality refers to cause and effect relationship between two pairs of variables in the system while, instantaneous-causality only shows none-zero correlation relation between two sets of variables. The result of pair wise Granger and instantaneous -causality tests show that BDG jointly Granger cause money supply and inflation (Table 8). Money supply in turn jointly Granger causes inflation and fiscal deficit to GDP ratio. Budget deficit with money supply also Granger causes inflation. Money supply growth individually Granger causes inflation but not vice versa.

Instantaneous Causality test also supports bi-directional causality between “inflation, BDG” and “money supply growth”; between “BDG. money supply” and “inflation”, and between “money supply growth” and “inflation”, Starting from the highly significant causality test, impulse in money supply helps to improve forecasting of inflation and in turn inflation instantaneous cause money supply growth.

Table 8: Granger-Causality and Instantaneous Causality test

Pair Variables	Granger-Causality direction First ⇒	⇐ second	Instantaneous Causality ⇔
"lnM2". "lnCPI"& "BDG"	1.0342	2.0743*	0.0431
"lnCPI". BDG"& "lnM2"	0.8137	3.2334**	8.2905**
"BDG". "lnM2"& "lnCPI"	3.9987**	0.5914	8.2837**
"lnCPI". "BDG"	1.5221	0.5565	0.0505
"lnCPI". "lnM2"	1.6509	4.1547**	7.8995**
"BDG". "lnM2"	0.6996	1.0984	0.1915

**denotes significance at a 5% level *denotes significance at a 10% level

Table 9: VAR model lag exclusion test

lag	lnM2-equation		lnCPI-equation		BDG-equation		Jointly	
	chi2	**Prob.**	**chi2**	**Prob.**	**chi2**	**Prob.**	**chi2**	**Prob.**
1	66.8308	0.000	68.62443	0.000	11.9241	0.008	99.97763	0.000
2	.4874088	0.922	10.99398	0.012	7.5124	0.047	18.37293	0.031

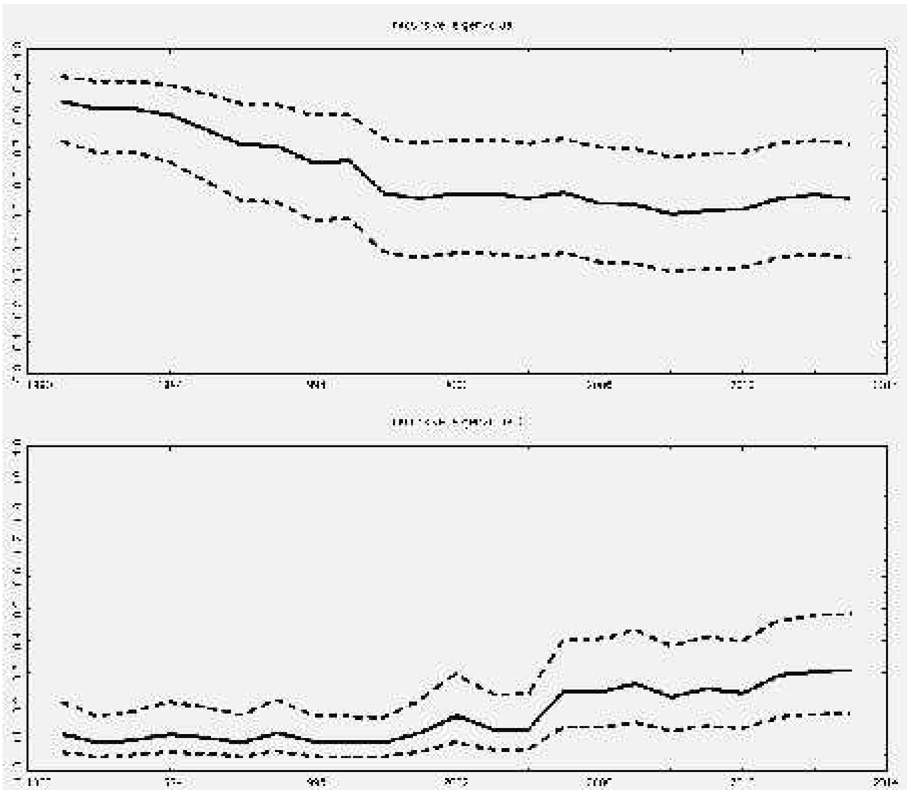
Combined with long run equation, this supports monetarist hypothesis (MH) of ‘inflation is monetary phenomena’. Impulse in budget deficit aids us in predicting money supply growth and inflation jointly but not individually. It is not clear whether budget deficit to GDP ratio directly affects inflation or not. However, budget deficit jointly with money supply aids to improve forecasting of inflation. The shock in budget deficit may transmit to inflation through money supply channel.

Lag exclusion test

According to Wald lag exclusion test procedure all coefficients of endogenous variables at lag two for all equations are jointly different from zero at 5% level of significance (Table 9). In other words, the lag order of all equations in the system is jointly two.

Model Stability Analysis

Figure 2: Recursive eigenvalues with 95% confidence band



Recursively estimated eigenvalues from VECM model reported with its 95% confidence band (Figure 1) show that the absence of parameter instability over time. Because of both eigenvalues lie within 95 % confidence bands, one can see that the absence of system instability. This diagnostic test shows that, our econometric model is correctly specified and the results can be used for further analysis.

6. Conclusion

This paper attempted to investigate the causal long-term relationship between broad money supply growth, inflation and budget deficit to GDP ratio in Ethiopia. All the variables are integrated of order one and the system consists of two co-integrating relations. Under such circumstances, vector error correction model (VECM) is appropriate model, since it offers better information compared to other data generating processes. The lag length for VEC model has been chosen at one based on AIC and FPE. Furthermore, the system contains normally and independently distributed random variables and its recursively estimated Eigen values appeared to be stable over time. Ethiopian annual data on broad money supply, consumer price index and budget deficit to GDP ratio from 1975 to 2012 were used in this study.

The results shows that the existence of long–term relationship between money supply and budget deficit in Ethiopia. On average 1% point increase in BDG leads to 1.56 % point raises in broad money supply keeping other factors constant. This is consistent with theoretical framework and it is also compatible with the empirical evidences found from other countries (Ignacio, 2008; Petraq, 2012). However, there is no evidence for its short run effect on money supply. Deficit financing through credit expansion obviously results in increasing money supply. Ethiopian government has been financing its deficit from domestic and foreign borrowing. Both are potentially affects money supply growth in the long run. Direct Advance from National Bank of Ethiopia takes the lion share of domestic borrowing (for example. 67.2% in 2011 and 58.5% in 2012) which has been directly contributed to money supply growth and it accounts 32% and 25% of broad money supply in 2011 and 2012 respectively (see MoFED. 2012). But. Granger causality analysis shows that the effect of budget deficit on money supply growth is only marginally significant at 90% confidence level.

On the other hand, in the long run budget deficit also significantly affects inflation. On average one point rises in percentage of budget deficit to GDP ratio induces inflation by 0.73 point in the long run keeping other things remain constant. This result is in line with the hypothesis of fiscal theory of price level. However, in the short run its effect on inflation is not significant. Granger causality analysis also shows that budget deficit not individually directly causes inflation but jointly with money supply it causes inflation in the economy. This indicates budget deficit affects inflation through money supply Channel. Therefore, the direct effect of budget deficit on inflation Ethiopia is not conclusive and needs further investigation.

In the long run growth of broad money supply significantly influences inflation. On average one percentage point rise in broad money supply leads to 0.62 percent rise in consumer price index in Ethiopia, keeping other factors constant. In the short run, inflation also influenced by monetary expansion (on average a percent rise in money supply induces 0.735 percent in inflation). This result is also supported by granger and instantaneous causality analysis. From these results, one can conclude that inflation in Ethiopia is more of monetary phenomenon. Since, there is instantaneous causality between inflation and money supply; increase in money supply induces inflation and this in turn further increases money supply and so on. Broad money supply has also positive effect on budget deficit in the long run. However, structural granger causality analysis doesn't support this statement. In the long run expansionary monetary policy aggravates fiscal imbalances and hence responsible for macroeconomic instability in Ethiopia.

As reviewed earlier, fiscal deficit, money supply and inflation in Ethiopia are interlinked in the long run. Budget deficit has contributed to money supply growth, monetary expansion has exerted inflationary pressure in the economy, and inflation in turn has been putting pressure on fiscal deficit. Hence, it is to be suggested that budget deficit in Ethiopia should be properly managed; ensuring transparency and accountability in fiscal operation; improving domestic resource mobilization, proper planning of government budget, reducing government expenditure on non productive activities and improving domestic revenue collection, administration system, broadening tax bases and prioritizing projects and activities. These may reduces inflationary pressure of fiscal deficit in the country. The most important to combat inflation in Ethiopia is monetary policy operation. The effectiveness of monetary policy in controlling inflation requires National Bank Ethiopian to possess some degree of autonomy. In addition to this, monetary authorities required to tightening monetary policy without affecting economic growth; adjusting money supply growth with GDP; ensuring fiscal and monetary policy coordination; improving the capacity of National Bank to properly manage financial sectors operation, increase reserve requirement, improving credit market operation.

The magnitude of causal long-term relationship among budget deficit, money supply growth and inflation could vary depending on the type of fiscal and monetary-policy regime, monetization and openness of the economy, as it has been explored in other studies. However, these issues are not covered in this study and open to further research in Ethiopia.

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Agricultural Technology Adoption and Rural Poverty: A Study on Smallholders in Amhara Regional State, Ethiopia

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Abstract

Poverty has remained to be the major development and policy challenge in Ethiopia. Studies indicate that poverty is higher in rural areas in all its measures. Since smallholder agriculture is the mainstay of rural dwellers, policies of the country intended to give priority to increasing the productivity of agriculture to challenge rural poverty. Consequently, different strategies were put in place since the 1994 reform period. Under the growth and transformation plan, whose tenure has just come to an end, intensification (through adoption of agricultural technologies) and structural change were sought to bring about smallholder 'productivity revolution' for a transformative growth in the sector and poverty reduction. Agricultural technology adoption is however limited in the country with greater geographical differences. We analyze smallholders' propensity to and intensity of agricultural technology adoption in Amhara Regional State using Double-Hurdle Model to identify the relative importance of the factors that explain the underlying choice. A modest attempt is also made to link technology adoption to household welfare using matching techniques of impact evaluation. The study is based on the Ethiopian Socioeconomic Survey (ESS, 2013/14) data of the Living Standards Measurement Study. The results corroborate the importance of policy support schemes, input market and physical infrastructure, poverty [capacity] to explain agricultural technology adoption. Considerable evidence on the positive welfare impact of technology adoption is documented which entails a tenable link between technology

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adoption and poverty reduction. However, a comprehensive policy framework is needed to tackle the capacity and physical access constraints to promote agricultural technology adoption.

Key words: technology adoption, poverty, double hurdle, PSM.
JEL code: C24, I32, Q12

1. Introduction

Food insecurity and poverty remain to be the major development and policy challenges in Ethiopia. The country is found at the tail of both the hunger index (76th out of 79 countries) of the International Food Policy Research Institute (IFPRI) and human development index (173th out of 187 countries with a score 0.396 in 2012) of the United Nation Development Program(Oxfam. 2012. UNDP. 2013). An interim report by the government indicates that the proportion of people below the poverty line stood at 29.6percent. The Disaggregated results show that those proportions in rural and urban areas for the year 2010/11 are 30.4 percent and 25.7 percent respectively (FDRE. 2012). Although it is recognizable that there is a substantial decline in poverty incidence (from 38.7 percent in 2004) and depth (from 0.083 in 2004 to 0.078 in 2010/11), the size and impact of the problem is still considerably worrisome. It is also indicated in the interim report that rural poverty is higher than urban poverty in all periods. More so, much of the decline in country level poverty is arguably attributed to the decline in urban poverty albeit poverty (measured in incidence and depth) has shown a declining trend both in rural and urban areas. The report associated the observed improvement to the pro-poor programs implemented by the government both in rural and urban areas. However, the distribution of income among the poor showed no improvement.

On the other hand, some studies showed that rural poverty is on an increasing trend since 2004. Studies based on the Ethiopian Rural Household Survey data, a unique longitudinal data over 15 years (1994-2009), found that rural poverty has shown a tremendous decline up to 2004 (Dercon *et al.* 2007) and then started to rise (Dercon *et al.*, 2011). Yet, movement into and out of the state of poverty – poverty dynamics – is high during all periods. These studies suggested that transition into and out of (chronic) poverty are related to the growth handicaps faced by the poor while the increase in rural poverty during 2004–2009 is closely related to local factors and high inflationary pressure. Although most of the growth stimulants (including agricultural extension packages and infrastructure) have fundamentally the same effect for the chronic-poor and the rest, the former face considerably severe growth handicap compared to the rest, leaving them permanently behind.

The agricultural sector is believed to be the key sector both for poverty alleviation and to materialize a transformative growth in Ethiopia. This, together with its major contribution to rural livelihood in the country where poverty is the highest, has placed the sector at the center of development and policy interventions (FDRE, 2012; FDRE, 2010). More than 80percent of the population lives in rural Ethiopia where its livelihood is tied to traditional agriculture which in turn is hinged to sporadic rainfall. As a result, agricultural growth and sustainability has become a priority in policy making in the country (Asfaw and Shiferaw, 2010; Pycroft, 2008; FDRE, 2010). Under the broader Agricultural Development Led Industrialization (ADLI) development strategy and pursuant to the prevailing structure of the economy, the policy environment has long been giving priority to the structural change and productivity of the pervasive peasant agriculture. Pushing the prevailing agricultural technologies to the frontier is argued in the ADLI framework to bring about productivity growth, inter alia, application of improved seeds, increased adoption of inputs (fertilizer. pesticide…) and expanding irrigation and infrastructure (Dercon and Zeitlin, 2009). However, the rate of technology adoption and its intensity in the country is very low even by sub-Saharan standard. For instance, the average adoption rate of modern fertilizer is estimated to be less than 33% of the total cultivated land and the average level of use of modern fertilizer is only 11kg per hectare which is very low compared to 48kg per hectare in Kenya. In addition, the loss of soil nutrients due to land degradation and improper use of animal dung is the highest in sub-Saharan Africa (Yesuf and Köhlin, FDRE, 2010).

Moreover, technology adoption in the country followed a clear spatial pattern as well as greater variations by crops. Amhara region is among those which are characterized by low technology adoption which is mostly attributed to fragmented land, environmental degradation, population and livestock pressure, and relatively low productivity. North Gondar zone can be recited in here for it is one of the least adopters in the country which is corroborated by a recent study that argued for a limited application of chemical fertilizer in all crops except *Teff* (Yu *et al*. 2011).

In response to the observed insufficient agricultural technology adoption and to promote intensification, several attempts have been made to identify the relative importance of factors that determine smallholders' technology adoption in Ethiopia and developing countries, at large. However, previous research generally focused on a mere characterization of farm households in terms of adoption in which the socioeconomic characteristics of farmers are used to explain adoption level. The more fundamental process in which farm households make choices regarding the adoption of the available technology based on the specific features of the technology (inter alia. suitability and linkage with farmers' indigenous knowledge and experience) has long been sidelined.

For a complete understanding of agricultural technology adoption and its effectiveness, research needs to equally focus on how smallholders' adoption choices and its intensity are explained by the peculiar features of the technology in point in relation to pre-existing farm knowledge. These factors are of vital importance not only for adoption decision but also for the effectiveness of the adopted technology. On the supply side, agricultural technologies are often introduced in a package program although most adopters use part of the package. And, the determinants and welfare impact of such variation in adoption is not well investigated in the study area and Ethiopia, in general.

The relationship between technology adoption and poverty reduction is yet ambiguous. The extant literature seemed to have focused on the contribution of technology adoption in poverty alleviation in which a positive impact of technology adoption on household wellbeing appeared to be a general consensus. Among the contributions that corroborate such a relationship, the EEA/EEPRI (2006) report documented that the introduction of improved seed and chemical fertilizer in a package program has generally a positive impact on productivity for although its impact on *Teff* production was found ambiguous (cited in (Brown and Teshome, 2008)). Most other studies also commend that technology adoption has a direct role on improving rural household welfare through increasing agricultural productivity (Asfaw and Shiferaw, 2010).

On the other hand, some studies argue that agricultural technology adoption depends on poverty status of households. Although agricultural technology adoptions have identical impact on the poor and non-poor, the poor have more capacity constraints to adopt. Moreover, Agricultural technology adoption is a high risk and high return choice. The farmers need to invest more to get the technology. Since the poor cannot insure their consumption against shocks like crop failure, they will generally limit themselves to low risk low return choices (Dercon *et al.*, 2007). Hence, poor people may not choose to adopt agricultural intensification schemes. This is very important yet an overlooked issue both in the literature and policy debates. The implication of this line of argument is that the poor smallholders refrain from adopting productivity enhancing technologies and face a type of vicious circle of poverty under the backdrop of no planned systematic intervention. However, this theoretical possibility shall be supported by empirical evidence which is argued missing in this particular study.

Against this backdrop, the objectives of this paper are twofold. First, it analyses the propensity to and intensity of agricultural technology adoption by smallholders to identify the relative importance of the factors that explain the underlying economic process. It then evaluates the impact, through increased productivity, of technology adoption on household welfare (poverty). With an overarching framework of the technology adoption–farm productivity–poverty reduction nexus, the study provides empirical evidence on the relationship between agricultural technology adoption and rural poverty in Amhara Region. For empirical focus, the study concentrates on adoption of chemical (inorganic) fertilizer. And analysis is made for three major crops.

2. Model and Estimation

2.1 Understanding Smallholders' Technology Adoption

Informed by microeconomic theories of the firm [farm], smallholders are modeled as producing agents which decide on the use of certain technology products based on its profitability. For instance, a smallholder chooses to apply chemical fertilizer on its farm if the productivity gain outweighs all the costs associated with the use of the fertilizer. Basically, observed level of adoption is an outcome of two distinct processes. The first stage involves the adoption decision of farmers and is commonly called participation decision. In the second stage, farmers decide on the intensity of use of the fertilizer. The standard Tobit model can be good candidates in modeling the adoption behavior of smallholders under no (capacity and information) constraints. However, two major drawbacks of Tobit can be considered here, especially from the perspective of our study. First, Tobit model assumes that decision to adopt a given technology and intensity of adoption are governed by fundamentally the same stochastic process. The same vector of parameters are assumed to determine the first and the second stages of decision. These rules out the possibility that a given variable has different marginal effects on the probability of adoption and intensity of adoption. It is also impossible to have different vectors of parameters for the two stages of decision under Tobit setting (Burke, 2009; Eakins, 2014).

Second, the Tobit model assumes that zero value is observed when the dependent variable is censored at zero. However, as explained in Cragg (1971), zero values may be observed due to other factors too. In the context of our study, there are varieties of demand and supply side constraints which can be fairly associated with the general low rate of agricultural technology adoption. The demand side constraints are reasonably related to income levels, access to credit and (most importantly. information. Farmers do not have complete information to decide on the profitability of the technology product. The supply-side constraints can be related either to low access to information, insufficient (incomplete) information or improper use of information. Above all, access to a given farm technology is not guaranteed. So, ruling out constraints does not seem appealing.

Farm households' choice to and level of technology adoption in the presence of constraints gave rise to three distinct subsamples (Amare *et al*., 2012). The first groups of farmers are well aware, have demand and adopt technology. The second groups do not want to adopt agricultural technologies for it is not profitable at current prices. The third groups want to adopt the available agricultural technology but cannot get it due to supply side constraints. Therefore, farmers' choice is observed after passing two hurdles. Based on this classification, our model is developed to consider three aspects of the fundamental choice process: decision to adopt (desired demand for) a given technology, access to the technology and intensity of adoption of the technology in question. It is under this backdrop that the use the Double-hurdle model to estimate the propensity to and intensity of technology adoption is justified appropriate.

A parametric Double-Hurdle Model is argued appropriate in modeling empirical studies in evolving sequential decisions in two stages. It was first proposed by Cragg (1971) and used in variety of empirical literature including health economics(Jones, 1989; Labeaga, 1999; Tauras, 2005), estimating expenditure(Yen and Jensen, 1996; Lin and Milon, 1993), labor economics. valuation studies (Saz-Salazar and Rausell-Koster, 2008; Oseni, 2015) and technology adoption(Islam *et al*., 2015; Akpan *et al*., 2012;

Hazarika *et al.,* 2015; Asfaw *et al.,* 2011; Gebremichael and Gebremedhin, 2014). The Double-Hurdle model is a generalization of the Tobit model designed to deal with survey data in which the decisions can be modeled as dependent. independent or sequential to each other(Gao *et al.,* 1995).

Following (Amare *et al.,* 2012; Asfaw *et al.,* 2011), we specify the double hurdle model as in what follows. Suppose now that for any individual farm household *i.* the desired demand for fertilizer is given by:

$$D^* = \beta' X_i + \mu_i \ldots \qquad \textbf{(1)}$$

Where *Xi* is a vector of determinants of demand. β is a vector of parameters. μ is Gauss-Markov's error term, and *'D^*' is* latent desired demand. In addition, assume that the farm household's access to fertilizer is given by

$$A^* = \varphi' Z_i + \varepsilon_i \ldots \qquad \textbf{(2)}$$

where *A** is latent variable denoting farm household's possibility of access to fertilizer supply; Z is vector of determinants of access to fertilizer; φ is vector of parameters and ε is Gauss-Markov's error term. These two equations are assumed to be independent of each other and divide the total sample in to three sub-samples.

1. Those households who adopt fertilizer (*D*>0 and A*>0*).
2. Those households who do not want fertilizer regardless of access for it (*D*<0*).
3. Those households who have positive desired demand to fertilizer but do not adopt due to lack of access (*D*>0 and A*<0*).

Hence, adoption of fertilizer is observed after it passes two thresholds: positive desired demand and access thresholds. Yet, an important decision of farm households is intensity of adoption, i.e.

$$Y_i = Y^* \text{ if } D_i > 0, A_i > 0 \qquad \textbf{(3)}$$

$$Y_i = 0, otherwise$$

$$Y^* = \text{©}' H_i + \text{¦}_i .$$

Where, H is a vector of variables; κ is vector of parameters and η is Gauss-Markov's error term (Beshir *et al.*, 2012). On the basis of this setting, the likelihood function for the observed demand is given by:

$$\ln(L) = \sum_{G1=1} \ln\left[\Phi\left(\text{¥}' Z_i / \text{¢}_{\text{«}}\right) * \text{¤}\left((D_i - \; X_i) / \text{¢}_{\text{«}}\right)\right] + \sum_{G2=1} \ln\left[1 - \Phi\left(\; ' X_i / \text{¢}_{\text{«}}\right)\right] + \sum_{G3=1} \ln\left[\Phi\left(\; ' X_i / \text{¢}_{\text{«}}\right) * \left(1 - \Phi(\text{¥}' Z_i)\right)\right] \ldots \qquad (4)$$

Where, ϕ and Φ are (resp.) probability density function (pdf) and cumulative distribution function (cdf) of standard normal variable (Asfaw *et al.*, 2011).

Double hurdle models with continuous response variable in the second stage are mostly estimated by specifying binary choice for the first hurdle and ordinary least square (OLS) regression for the second hurdle, assuming that the distribution of the error terms is bivariate normal. However, in our case, the distribution of the response variable for the second hurdle was highly skewed. Thus, normality assumption doesn't seem to hold. The first natural choice would be logarithmic transformation of the response variable. However, such transformation may lead to bias in estimating elasticities as discussed in Tauras (2005). More so, retransformation is not easy in the case of heteroscedastic errors (Ornelas-Almaraz. 2012. Tauras. 2005).

Whenever such distributional issues arise, GLM with log-link relationship and appropriate distribution family is preferred (Tauras. 2005. Ornelas-Almaraz. 2012. Manning and Mullahy. 2001). GLM provides a flexible option to relax the normality assumption with no need for retransformation as predictions are based on raw scale (Salmon and Tanguy, 2015; Jones, 2010;. Tauras, 2005). However, it is worth mentioning that GLM estimators may be less precise especially for data with heavier tails in log scale (Baser, 2007; Manning *et al.,* 2002). Our study uses GLM with log link and Gaussian distribution in the second hurdle.

2.2. Welfare/Poverty Impact of Agricultural Technology Adoption

Evaluation of the welfare [poverty] impact for agricultural technology adoption has something to do with the determination of ex-post measured outcomes of welfare indicators for technology adopting smallholders in comparison to the counterfactual [outcomes of welfare indicators had the smallholders not adopted the technology product] (Heckman and Vytlacil, 2005). In effect, technology adoption is considered as a treatment [intervention] which is however subject to non-random assignment to smallholders and self-selection.

More so, the outcome variables of welfare indicators are not observable in both treated and untreated states. This necessitate the statistical construction of a suitable counterfactual in the untreated state conditional on receiving treatment (Diaz and Handa, 2004). For our study of exploring the welfare impact of agricultural technology adoption is based on observational data than in an experimental setting. the most widely employed technique of Propensity Score Matching is used to settle the counterfactual problem (Austin, 2011; Steiner and Cook 2013). Apparently, the validity of matching technique relies on certain assumptions. The first basic (identification) assumption is the conditional independence assumption. The assumption states that outcomes in the untreated state are independent of program participation conditional on a particular set of observable characteristics (Diaz and Handa, 2004; Khandker *et al*., 2010). Suppose X denotes a set of observable characteristics, and T is a dummy variable for treatment. If the parameter of interest is average treatment effect (ATE), the identification assumption is given by:

$$\left(Y^t, Y^c\right) \perp T \mid P(X). \qquad \textbf{(5)}$$

Where the symbol $\perp$ indicates independence and $P(X)$ is the propensity score. Y^t and Y^c indicate the outcome of interest for treated and untreated groups respectively. For estimation of the treatment effect on the treated (TOT), the assumption can be relaxed to

$$Y^c \perp T \mid P(X).. \quad \textbf{(6)}$$

The second assumption of PSM is the common support condition which requires that the treatment observations have comparison observations nearby in the distribution of the propensity scores. It is given by.

$$0 < P(T = 1 \mid X) < 1.. \quad \textbf{(7)}$$

For estimation of TOT. the common support condition can be relaxed as

$$P(T = 1 \mid X) < 1.. \quad \textbf{(8)}$$

Imposing conditional mean independence assumption, our parameter of interest, average treatment effect on the treated (ATT), is evaluated as:

$$ATT(x) = E(Y_1^t \mid T = 1, P(X)) - E(Y_0^t \mid T = 1, P(X)) \quad \textbf{(9)}$$

The second term in equation (9) is the average welfare outcome of treated individuals had they not been treated. However, this is not observable in cross-sectional studies like ours. Instead, corresponding outcomes for untreated observation is estimated as

$$ATT(x) = E(Y^t \mid T = 1, P(X)) - E(Y^c \mid T = 0, P(X)).. \quad \textbf{(10)}$$

The difference between (9) and (10) is attributed to selection bias. In our study, balancing scores are estimated from logit model and the common support condition was imposed. Matching estimators, based on (Diaz and Handa, 2004; Khandker *et al.*, 2010), have the general form as:

$$ATT = \frac{1}{N_t}\left[\sum_{i \in T} Y_i^{tT} - \sum_{j \in C} \mu(i, j) Y_j^c\right]... \quad \textbf{(11)}$$

Where *N is* the number of participants and; $\mu(i, j)$ represents a weighting function that depends on the specific matching estimator. Thus, the choice of the matching technique is crucial. While it is possible to select a matching technique based on its performance in minimizing bias, we prefer to use three commonly used matching criteria that, we believe, complement each other. Nearest Neighbor Matching (NNM), Radius Matching (RM) and Kernel Matching (KM) are used to make sure that our results are robust. As discussed in Khandker *et al.* (2010). NNM matches each treatment unit to a comparison unit with the nearest propensity score. However, the difference in propensity score between the closest treatment and control units may still be high. This may be avoided by specifying the maximum propensity score distance (caliper) which justifies the use of Radius Method. On the other hand, Kernel Method is a nonparametric matching estimator which uses weighted average of all nonparticipants to construct the counterfactual match for each participant. Major advantage of this method over the other two is that more information is used (Khandker *et al.,* 2010*,* Caliendo and Kopeinig, 2005). Estimation was done using STATA 12 software.

The Foster-Greer-Thorbecke (FGT) index (Foster *et al.*, 1983), which is defined as in what follows, is used to measure the poverty status of smallholders.

$$P_a = \frac{1}{N}\sum_{i=1}^{q}\left(\frac{z - yi}{z}\right)^a . \quad \textbf{(12)}$$

Where, '*z*' is the poverty line; y is real Percapita consumption expenditure and '*a*' is the poverty aversion parameter. The poverty incidence, depth and severity are measured by changing the values of 'a' in the formula. The

2010/11 national poverty line estimate, adjusted for price changes is used to compute the FGT indices (FDRE, 2012).

3. Data and Descriptive Statistics

The study is based on data from the Ethiopian Socioeconomic Survey (ESS. 2013/14). The ESS is a collaborative project between the Central Statistics Agency of Ethiopia (CSA) and the World Bank Living Standards Measurement Study- Integrated Surveys of Agriculture (LSMS-ISA) team. It primarily targets on developing and implementing a multi-topic survey that meets Ethiopia’s data demand and gaps and is believed to be of high quality, accessible to the public and aligned with the National Strategy for the Development of Statistics (NSDS).

The survey covers rural areas, large towns and small towns in all regions except some exceptional zones of Afar and Somali region. Sample units were selected using stratified two stage sampling procedure and the sampling frame for rural areas was based on 2013/14 Agricultural sample survey of the CSA. A total of 5.262 sample households were selected for the whole country of which 20.5 percent (1080) are drawn from Amhara Region. The data is argued to be representative for regional estimation in the most populous regions (Amhara, Oromiya, SNNP and Tigray) (CSA, 2011/12). As such, the survey covered 61 rural, 15 medium and large urban and 10 small urban enumeration areas in Amhara regional state. The data for all rural households in Amhara region is used in the study. And. the analyses on the pattern of technology adoption and its implied impact on rural poverty are made based on three crops, namely *Teff*, Wheat and Maize.

3.1 Distribution of Plot Size, Technology Adoption and Intensity

A simple exploration of the data offer important insights on adoption of agricultural technologies and intensity of use. It is apparent from Table 1 that about 65% of the samples adopt chemical fertilizer with a small variation across crop type. This is consistent with previous results in other parts of the country and sub-saran Africa (Terefe *et al.*, 2013; Endale, 2011). On the other hand, the adoption of improved seed appeared small when compared to chemical fertilizer.

Table 1: Distribution of plot size and technology adoption by crop category (%)

Crop Code	Improved Seed (percentage of plots)	Fertilizer Use (percentage of plots)		
		Chemical Fertilizer	Manure	Compost
MAIZE	34.75	66.15	46.79	18.0
TEFF	3.68	66.58	9.50	8.0
WHEAT	9.80	63.91	17.40	15.86
Total	16.74	65.77	25.31	13.62

On average, only 16.74% of the plots use improved seeds with a large variation between crop types. The adoption of improved seeds is larger for maize followed by wheat. The application of organic fertilizers (manure and compost), as indicators of pre-existing knowledge and technological practices, is way below the application of chemical fertilizers with considerable variation across crops. The data entails a significant variation in the intensity of improved seeds and fertilizer application, as well, from Table 2, the average use of urea and dap in kilogram per hectare of fertilized (for the three crops) land is 74.28 and 89.91 respectively. And. the intensity of chemical fertilizer use is generally larger for maize followed by wheat.

Table 2: Distribution Fertilizer use by crop category (kg/ha)

Fertilizer Type	Crop Type			
	Maize	***Teff***	**Wheat**	**Total**
Urea	99.15	52.85	68.89	74.28
Dap	115.62	66.36	86.68	89.91
Total (Urea + Dap)	215.16	119.35	155.21	164.29

4.2 Average Productivity and Technology Adoption

An important issue worth exploring is the relationship between land productivity (yield) and application of chemical fertilizer in comparison to pre-existing technological practices. An insightful result on average yield under different technology regimes is presented in Table 3. The average yield is about 1461kg/ha with significant variation across crop types. Maize gives highest yield per hectare followed by wheat. Another important feature in the table is the impact of fertilizer use on productivity. There is a negative differential in productivity between adopters and non-adopters of both organic and inorganic fertilizer.

An exception in this respect is Maize for which all types of fertilizers except compost have negative effect. This is not surprising for many variables which affect the relationship are not controlled. A typical example is crop damage. Crop damage is reported on about 22% of the total plots taken in the sample, and maize plots experience the largest damage both in terms of the number of plots with reported damage (30%) and the perceived share of damage from the total crop in the plots (40%). The three major causes of the damage have been insects (21%), shortage of rain (20%) and hail (13%) [see Appendix 2]. More so, Maize is grown in arid and semi-arid parts of the region that makes the crop yield vulnerable to weather related and other shocks, as a result of which, the productivity impact of fertilizer is so unpredictable.

Table 3: Average Yield of Crops (in kg/ha) under Different Fertilizer Regimes

Crop Code	Fertilizer Regimes									Total
	Chemical Fertilizer			Manure use			Compost			
	No	Yes	Diff	No	Yes	Diff	No	Yes	diff	
Maize	1990.9	1887.6	103.3	2163.2	1673.7	489.7	1842.7	2166.8	-324.1	1921.7
Teff	971.8	1153.8	-181.9	1073.2	1081.2	-8	1215.5	1337.6	-122.1	1092.8
Wheat	1161.0	1423.9	-262.9	1256.5	1497.9	-241.4	1454.7	1457.7	-3	1329.8
Total	1393.6	1495.6	-101.9	1585.0	1568.3	16.7	1529.1	1780.3	-179.2	1461.1

Generally, further exploration of the summary statistics for the study variable and its covariates offered appealing results in view of the process underpinning the observed technology adoption and intensity of use [See Appendix 1]. A simple mean comparison test between adopters and non-adopters of fertilizer indicates that a set of household characteristics, including education and livestock wealth (in TLU), are significantly larger for adopters. The mean distance from markets, all weather road and urban centers is significantly larger for non-adopters indicating that non-adopters have lesser access to market and technology information which in turn results in slow diffusion of farm technology as well as high transportation cost. There is also a significant variation in the characteristics of plots with and without chemical fertilizer use. More so, adopters have significantly higher mean values in terms of microclimate indicators like potential wetness index and elevation, and lower mean values in terms of plot slope and distance from homestead.

Other factors such as extension contact, advisory service, the use of manure and compost and credit have also statistically significant association with adoption of fertilizer. The first two are related with farmers' access to information on fertilizer and its profitability while access to credit indicates farmers' ability to finance their purchase of modern technology under cash constraints. The institutional support system has long been a major factor for modern technology adoption and productivity of smallholders. However, such support has remained low. The use of manure and compost (organic fertilizer) has negative association with adoption of chemical fertilizer with a possible explanation that the pre-existing technology practices are preferred substitutes to inorganic chemical fertilizers.

4. Estimation Results and Discussion

4.1 The Probability and Intensity of Agricultural Technology Adoption

The estimation of the probability equation for farm household's technology adoption, application of fertilizer on the farm, and the level of technology adoption is performed under the double-hurdle model assumptions. The estimated model relates smallholder farm households' adoption decision and the intensity of technology use to a long list of socio-economic factors in Amhara Region. For the interest of interpretation and discussion, we grouped such factors into household characteristics, plot characteristics and micro-climate factors, institutional factors and policy support. The double-hurdle model estimation result is presented and discussed in this section.

4.1.1 Explaining Technology Adoption in Amhara Region

Understanding technology adoption goes beyond the simple characterization of factors as determinants of the technology use to evaluating the relative importance of competing theoretical explanations. Evidence from the estimated relationship on the widely discussed socio-economic factors and technological practices and smallholders' technology adoption entails more on this (Table 4). From among the household characteristics, formal education and sex have the expected sign but in significant. Off farm employment of the household head significantly increase the probability of adoption, suggesting that smallholders diversifying into the off-farm economy and credit constrained finance chemical fertilizer through off farm earnings. About two-third of the participants in off farm activities have no credit access and this strengthens the argument. Similarly, land area has significant positive impact on propensity to adopt inorganic fertilizer. Land and off farm employment are poverty related variables. Especially land is the major component of wealth of rural households. A simple mean comparison test indicates that the land holding of the poor[4] is significantly lower than the non-poor [See Appendix 5]. Our estimation result shows that the probability of adoption increases with an increase in size of farm land owned.

[4]Poverty is calculated based on the national poverty line after the households' annual Percapita expenditures are adjusted for inflation. See FDRE 2012, Ethiopia's Progress Towards Eradicating Poverty: An Interim Report on Poverty Analysis Study In: Directorate, D.P.A.R. (ed.). Addis Ababa: Ministry of Finance and Economic Development.

Agricultural market (input and output) and physical infrastructure constitutes another important set of factors that influence smallholder's technology adoption. Accordingly, distance from the nearest all weather road, nearest market and zonal town have also negative and significant impact on the probability of adoption.

The marginal effects (for the total sample) indicate that at average an increase in distance from the nearest all weather road and nearest market by 1 kilometer results in a decrease in the likelihood of chemical fertilizer adoption by 0.013 and 0.0016, respectively [see Appendix 4]. Therefore, in comparison road infrastructure has the strongest impact. Lack of road infrastructure is one of the major bottle necks which affect farmers' adoption decision in different ways. First, lower road infrastructure increases the transportation cost for chemical fertilizers and thus creates a large difference between the actual price and the price farmers' face in the input market. It also reduces competition between input suppliers resulting in little choice available for farmers. Second, poor infrastructure reduces the profitability of a given technology. In the output market, it increases the difference between farm-gate price and the actual market price and creates geographic barrier restricting local demand to depend only on local supply. If there is information asymmetry, it is possible for middlemen with better information to expropriate information rent from farmers. Poor road infrastructure is also associated with slow diffusion of agricultural technology. Distance from the nearest market and proximity to urban center also have similar effect.

Institutional support factors are considered equally important to understand smallholders' technology adoption. And, this is supported by the empirical evidence. Credit and extension appeared important determinants of adoption. Around 40% non-adopters cite lack of financial capital as their major reason for not adopting chemical fertilizer. The two major reasons for inability to access credit, as reported by respondents in the study area, are inability to pay previous loans (48.05%) and inadequate service (13%), implying pervasive credit constraint for smallholders [See Appendix 6].

Table 4: Estimation Results of Smallholders' Propensity to Technology Adoption

Variables	Probit model. Dependent variable: adoption			
	Maize	***Teff***	**Wheat**	**Total sample**
Household characteristics				
Sex	-0.0233	-0.303	-0.0743	-0.0858
	(0.213)	(0.287)	(0.265)	(0.131)
Age	-0.0124*	-0.00630	-0.0106	-0.00901**
	(0.00527)	(0.00597)	(0.00570)	(0.00295)
Education	-0.0150	0.0512	0.0592	0.0376
	(0.0471)	(0.0538)	(0.0452)	(0.0252)
Land area (hectare)	2.504***	1.352	-0.0397	0.796**
	(0.685)	(0.739)	(0.420)	(0.276)
Off farm employment	0.155	0.331	1.183***	0.647***
	(0.316)	(0.400)	(0.357)	(0.185)
Input market and infrastructure				
Distance from road all weather road	-0.0193*	0.00509	-0.0205**	-0.00699*
	(0.00836)	(0.00620)	(0.00682)	(0.00324)
Distance from market	0.00186	-0.0153***	-0.00878**	-0.00906***
	(0.00384)	(0.00377)	(0.00331)	(0.00172)
Distance from zonal town	-0.00687***	0.00761***	-0.00410**	-0.000880
	(0.00157)	(0.00184)	(0.00144)	(0.000751)
Institutional support				
Extension	1.743***	2.460***	2.103***	1.987***
	(0.184)	(0.250)	(0.187)	(0.0997)
Credit	0.212	0.526**	0.487**	0.341***
	(0.165)	(0.202)	(0.186)	(0.0935)
Use of organic inputs				
Manure use	-1.077***	-0.651*	-0.858***	-0.981***
	(0.168)	(0.254)	(0.260)	(0.106)
Compost use	-0.148	-1.276***	-0.622*	-0.572***
	(0.198)	(0.293)	(0.277)	(0.123)
Plot characteristics				
Plot distance from home	-0.0541	-0.0880	-0.0252	-0.0264
	(0.0610)	(0.0714)	(0.0438)	(0.0285)
Soil quality (poor=1)	0.165	-0.376**	-0.0816	-0.149*
	(0.123)	(0.130)	(0.117)	(0.0620)
Plot slope	-0.0464***	-0.0284***	-0.0115	-0.0285***
	(0.0128)	(0.00837)	(0.00774)	(0.00470)
Plot potential wetness index	0.0531	-0.00738	-0.0586	-0.0264
	(0.0597)	(0.0621)	(0.0310)	(0.0209)
Altitude	0.00123***	0.000800**	0.000272	0.000596***
	(0.000342)	(0.000269)	(0.000238)	(0.000112)
Agroecology	-0.914**	-0.278	-0.297	-0.361**
	(0.333)	(0.257)	(0.200)	(0.131)
_cons	-1.503	-1.677	2.091*	0.271
	(1.111)	(1.259)	(0.970)	(0.463)

Akin, plots under extension are more likely to adopt chemical fertilizer in the region. Agricultural extension is the major instrument for dissemination of outputs of agricultural research. In Ethiopia, though agricultural extension has a long history, the dissemination of technology has been less than expected. Agricultural extension affects technology adoption decision in many ways. First, extension workers give training and advisory service to farmers which increase human capital and information access. Second, agricultural extension is mostly coupled with input distribution and farm credit. Third, it is the major channel through which agricultural research and development outputs are transferred to smallholders.

Plot characteristics and microclimate variables are another set of factors considered in explaining smallholders' technology adoption, mainly to account for varying plot quality and unobserved differences between agro-ecological zones. The three crops are grown in two major agro-ecological zones of the region: Semi-arid and sub-humid. The result shows that the likelihood of adoption in semi-arid areas is higher and significant for maize. On the other hand, plot slope and altitude have negative and significant effect on adoption. The probability of adoption decreases with deteriorating soil fertility indicating that framers are less likely to adopt inorganic fertilizer on poor quality plots. Another important implication of the result is the relationship between adoption of inorganic and organic fertilizers [See Appendix 7]. The use of manure and compost has strong negative impact on the adoption of inorganic fertilizer corroborating the result of possible substitutability in the descriptive analysis.

4.1.2. Explain the Intensity of Technology Adoption in Amhara Region

Study of agricultural technology in relation to smallholder productivity and implied impacts on poverty reduction will be fairly complete when analysis of farm households' propensity to technology adoption is substantiated to analysis of the intensity of technology use. In line with this strand of thinking, intensity equation is estimated for fertilizer use, the result of which is presented in Table 5. Household characteristics such as age and livestock ownership have negative and significant effect while education has positive and significant effect. The negative effect of livestock ownership on intensity of use may be due to that livestock ownership increases households access to manure which they use as a substitute for chemical fertilizer. Given the transportation cost, poor infrastructure and other constraints, farmers may prefer to use manure though livestock ownership also relaxes their cash constraint. Similar results were found by other studies(Hailu *et al.*, 2014; Kassie *et al.*, 2009). The effect of off farm employment is mixed.

Off-farm employment has positive and significant effect for *Teff* and wheat but negative effect for maize. On the other hand, access to all weather roads and other market related variable has mixed effects by crop type but are not significant for the total sample. Access to extension has a positive and significant effect on intensity of adoption which, as discussed in the adoption decision part above, may be due to that access to extension is the major way through which farmers get technology information and other services important for. Plot size has a negative and significant effect on intensity of fertilizer use. With regard to plot characteristics that are related with microclimate, the results indicate positive and significant effects of potential wetness index of soil, altitude and agro-ecology.

Table 5: Estimation Results of Smallholders' Intensity of Technology Adoption

GLM	Dependent Variable: Intensity of Adoption (amount of fertilizer in kilogram per hectare of land under chemical fertilizer). logarithm link and Gaussian distribution			
	Maize	***Teff***	**Wheat**	**Total sample**
Household characteristics				
sex	0.302*	-0.0145	-0.421	0.472*
	(0.130)	(0.199)	(0.526)	(0.200)
age	-0.00773**	-0.0156**	-0.111***	-0.0122**
	(0.00290)	(0.00510)	(0.0254)	(0.00429)
Education	-0.0126	0.0642**	0.288***	0.164***
	(0.0235)	(0.0224)	(0.0490)	(0.0138)
Household size	0.00203	0.0765*	0.444**	-0.0964**
	(0.0258)	(0.0304)	(0.136)	(0.0309)
Off farm employment	-0.217	0.406*	1.134**	-0.836**
	(0.145)	(0.198)	(0.440)	(0.318)
Livestock ownership (tlu)	-0.0390*	-0.00209	-0.850***	-0.153***
	(0.0174)	(0.0243)	(0.183)	(0.0312)
Input market and infrastructure related				
Distance from road all weather road	-0.0111	-0.00132	-0.179***	-0.00914
	(0.00664)	(0.00469)	(0.0477)	(0.00468)
Distance from market	-0.00384	-0.00439	0.0273***	0.00215
	(0.00222)	(0.00262)	(0.00757)	(0.00175)
Distance from zonal town	-0.000834	0.00348*	0.0115**	0.00206
	(0.00120)	(0.00156)	(0.00382)	(0.00126)
Institutional support				
Extension	0.378*	0.823***	1.203**	0.848***
	(0.156)	(0.196)	(0.401)	(0.174)
credit	-0.0446	0.144	-0.454	-0.00174
	(0.0877)	(0.134)	(0.296)	(0.106)
Plot characteristics				
Agro- ecology	0.555	0.370	3.580***	0.490*
	(0.303)	(0.248)	(0.905)	(0.249)
Plot size	-0.853**	-2.812***	-24.78***	-7.780***
	(0.325)	(0.596)	(3.043)	(0.836)
Plot slop	-0.00904	-0.0285**	0.00957	0.00619
	(0.0100)	(0.00944)	(0.0144)	(0.00439)
Plot wetness index	0.00587	0.00964	0.147*	0.0876**
	(0.0277)	(0.0335)	(0.0681)	(0.0288)
Altitude	0.000456*	0.0000351	0.00184***	0.000712***
	(0.000208)	(0.000174)	(0.000315)	(0.000128)
Constant	4.583***	4.772***	0.301	2.770***
	(0.678)	(0.814)	(1.603)	(0.606)
N	661	415	653	1729
Standard errors in parentheses	*** p<0.05. ** p<0.01. *** p<0.001**			

4.2 Welfare/Poverty Reduction Impact of Technology Adoption

Rural poverty reduction and food security has long remained to be the priority of poor agricultural economies, of which Ethiopia is an excellent case in point, in introducing agricultural innovations. Evidence-based policy choices can be motivated in this particular area with the analysis of welfare/poverty impacts, through productivity growth, of technology adoption. This section presents a modest attempt in this direction in which the impact of fertilizer use on household welfare is analyzed and discussions of the results ensue. To fix ideas, we use (1) propensity score matching technique and (2) simple comparison of poverty incidence, depth and severity between adopters and non-adopters of fertilizer. Logit model is used to compute the propensity scores in the first method and FGT curves are fit letting the poverty line to vary in the interval [0.7562] to ensure robust comparison in the later[5].

4.2.1 Comparison of Poverty Indices by Technology Adoption

The poverty rate for the region is estimated at 28.8%. only slightly less than the 2010/11 estimated poverty rate for the rural Amhara which was estimated at 30.7%(FDRE. 2012). This indicates that no significant improvement has been made in reducing rural poverty in the region for the last three years until 2013/14. On the other hand, it is evident from Table 6 that adopters have lower outcomes in terms of headcount, depth and severity of poverty. The poverty headcount for adopters is 20.8% while the same for non-adopters is 38.6%. The poverty curves are also fitted to make the comparison independent of the choice of poverty line [See Appendix 8]. The poverty incidence, depth and severity curves show a clear dominance for non-adopters in that adopters have lower incidence, depth and severity at all possible poverty lines in the range [0. 7526].

[5]The upper limit is selected to be twice the poverty line considered in our analysis.

Table 6: Poverty Headcount. Depth and Severity of for Adopters and Non-Adopters

Index	Adopter	Non-adopter	Total
Head count [6]	0.208281 (0.023613)	0.386223 (0.031795)	0.287942 (0.019529)
Depth	0.096318 (0.012774)	0.174695 (0.017320)	0.131406 (0.010550)
Severity	0.057345 (0.008879)	0.104598 (0.012231)	0.078499 (0.007383)

This gives a clue on the positive welfare (poverty reduction) impact of technology adoption. However, it is worth mentioning that such comparison doesn't account for problems of confounding which necessitates' impact evaluation proper' for it will single out the impact of adoption. Simple comparison of poverty by adoption status may correctly reflect the effect of technology adoption as poverty its self may the factor for not adopting agricultural technology. Therefore, we use propensity score matching technique to evaluate the impact of technology adoption under statistically controlled environment.

4.2.2 Estimation of Average Treatment Effects for Technology Adoption

The ATT impact of agricultural technology adoption on poverty reduction (welfare) was estimated using Kernel Matching. Nearest Neighborhood Matching and Radius Matching Methods. Estimated average treatment effects from the three matching methods are presented for purposes of comparison and robustness check [Table 7]. For the interest of clarity, the covariate balancing test procedure is performed to check whether the distributions of relevant covariates of adoption are balanced before and after matching, once the assumptions of the model are satisfied [Table 8].

[6] Standard errors in parenthesis

Table 7: Summary of Covariate Balancing Test

Algorithm	Psedo R^2		LR ¡^{2} (p-values)		Mean bias		Total % |bias| reduction
	Before matching	After matching	Before matching	After matching	Before matching	After matching	
NNM	0.160	0.013	117.88 (0.000)	11.11 (0.196)	30.9	6.6	78.6
Kernel	0.160	0.006	117.88 (0.000)	5.33 (0.722)	30.9	6.0	80.58
Radius	0.160	0.005	117.88 (0.000)	4.66 (0.793)	30.9	5.5	82.2

The likelihood ratio test for joint significance of the covariates is strongly significant before balancing and insignificant after balancing for all matching algorithms. In addition, the pseudo R^2 is very small after balancing indicating that the model balances the covariates between adopters and non-adopters. On the other hand, the bias minimizing matching algorithm is found to be the radius matching. Caliper size is another important point to be noted. In our case, (for NNM and Radius matching algorithms) caliper size of 0.056, determined based on the recommended way as 1/4th of the standard deviation of the propensity score. is used (Rosenbaum and Rubin, 1985).

It is evident from the result in Table 8 that technology adoption significantly improves household welfare (reduce poverty) as measured by Percapita consumption expenditure. Per capita consumption expenditure has increased by about 16.9% and 23.9% with the KM and RM techniques, respectively. The estimated positive impact of agricultural technologies supports the theoretical explanations argued.

Table 8: Estimation of Average Treatment Effect on the Treated

Matching Method	N		ATT	Std error	t-value
	Treated	Control			
Kernel matching (KM)	306	232	0.169	0.081	2.098
Nearest neighbour (NNM)	306	105	0.154	0.109	1.407
Radius matching (RM)	306	232	0.239	0.078	3.084

Sensitivity of the average treatment effect in the presence of unobserved heterogeneity between the treatment and control groups is tested using Rosenbaum bounds test [See Appendix 9]. The results show that the upper and lower bound estimates of significance levels for changes in gamma values at 0.05 intervals between 1 and 2 are zero, ensuring the robustness of the estimated ATT.

5. Conclusion and Policy Implication

The governments in developing countries, where structural transformation is yet to take place, have long been through agriculture led growth to address development challenges of poverty and food security. Agricultural innovation through enhanced technological capabilities has is emerging as a consensus paradigm in which systems of agricultural research and development, technology transfer and adoption are seriously considered to go about. Under the growth and transformation plan recently concluded. intensification (through adoption of agricultural technologies) and structural change were sought to bring about smallholder 'productivity revolution' for a transformative growth in the sector and poverty reduction. Agricultural technology adoption is however limited in the country with greater geographical differences. In view of this, we analyze smallholders' propensity to and intensity of agricultural technology adoption in Amhara Regional State using Double-Hurdle Model. The Ethiopian Rural Socioeconomic Survey (ESS. 2013/14) data of the Living Standards Measurement Study is used to estimate key relationships. The results corroborate the importance of policy support schemes. input market and physical infrastructure, poverty [capacity] to explain agricultural technology adoption. Considerable evidence on the positive welfare impact of technology adoption is also documented which entails a tenable link between technology adoption and poverty reduction policy endeavors. On the basis of this findings, the study urges for comprehensive policy frameworks to tackle the capacity and physical access factors which deter farmers from adopting agricultural technology..

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Appendices

Appendix 1

Variable	Chemical fertilizer adoption			
	No	Yes	Total	T-value
	Household Characteristics			
Age	50.13	46.85	48.68	5.2
Household size	**5.16**	**5.20**	**5.18**	**-0.51**
Education	**.43**	**.82**	**.69**	**-4.78**
Number of oxen	**1.13**	**1.52**	**1.38**	**-8.6**
Livestock (TLU)	**3.50**	**3.9**	**3.8**	**-3.1**
	Market Access and technology diffusion			
Distance from woreda town (km)	**26.54**	**18.41**	**21.22**	**11.22**
Distance from the nearest asphalt (km)	**37.00**	**34.51**	**35.36**	**1.34**
Distance from the nearest weekly market	**13.2**	**8.7**	**9.78**	**8.70**
Distance from major urban	**92.40**	**70.60**	**78.10**	**7.37**
	Plot Characteristics			
Distance from homestead	**1.00**	**.833**	**.926**	**1.71**
Plot Slope (percent)	**20.33**	**11.37**	**14.47**	**16.12**
Plot potential wetness index	**12.24**	**12.95**	**12.7**	**-6.80**
Plot size (hectare)	**.137**	**.198**	**.164**	**-9.13**
Plot elevation	**2085**	**2206.6**	**2164**	**-5.97**
	Average crop yield in kilogram per hectare			
Crop yield (total sample. KG)	**1393.6**	**1495.58**	**1461**	**-0.71**
Crop yield (Maize)	**1990.9**	**1887.6**	**1921.70**	**0.4**
Crop yield (*Teff*)	**971.8**	**1153.75**	**1092.76**	**-0.6**
Crop yield (Wheat)	**1160.97**	**1423.9**	**1329.79**	**-1.8**

For categorical variables (percent)

Variable		Adopt		Total	χ^2 (P-value)
		No	Yes		
Extension		13.67	75.71	41.26	867.9(0.000)
Manure		78.49	16.53	38.56	568.1(0.000)
Compost		42.39	12.65	23.28	173.35(0.000)
Certified		75.9	80.2	77.79	5.21(0.023)
	Good	31	38	34	
Soil quality	Fair	47	44.7	46. 06	14.1 (0.001)
	Poor	21.73	17.21	19.72	
Sex(male=1)		87.91	89.37	88.55	1.1405(0.286)
Literate		35.92	38.95	37.26	2.1439(0.143)
Credit		20.39	50.00	33.53	215.80(0.000)
Advisory service		74.52	95.64	83.89	181.08(0.000)
Offarm Employment		7.1	4.53	5.67	6.7653(0.009)

Appendix 2

What is the cause of damage of [Crop]?

	Freq.	Percent	Cum.
Too Much Rain |	40	9.41	9.41
Too Little Rain |	77	18.12	27.53
Insects |	75	17.65	45.18
Crop Disease |	30	7.06	52.24
Weeds |	51	12.00	64.24
Hail |	47	11.06	75.29
Frost |	1	0.24	75.53
Floods |	22	5.18	80.71
Wild Animals |	9	2.12	82.82
Birds |	1	0.24	83.06
Depletion of Soil |	30	7.06	90.12
Bad Seeds |	10	2.35	92.47
Other Specify |	32	7.53	100.00
Total |	**425**	**100.00**	

Appendix 3: Combined average Marginal effects from the double hurdle model (for the total sample)

Variable	dy/dx	Std. Err.	z	P>|z|
sex*	9.944333	4.77832	2.08	0.037
age	-.5473838	.15157	-3.61	0.000
educat~n	5.493141	1.1088	4.95	0.000
agroec~y*	5.974511	6.95786	0.86	0.391
area_h~e	-203.391	30.456	-6.68	0.000
dist_r~d	-.4154768	.14552	-2.86	0.004
dist_m~t	-.1405554	.06623	-2.12	0.034
dist_a~r	.0389304	.03852	1.01	0.312
offfarm*	-10.25094	5.97141	-1.72	0.086
extens~n*	67.35615	10.433	6.46	0.000
soil_q~y	-3.312054	1.50679	-2.20	0.028
dist_h~d	-.5872526	.64412	-0.91	0.362
credit*	7.481162	4.12205	1.81	0.070
manure*	-20.58218	4.23779	-4.86	0.000
compost*	-12.36074	3.37167	-3.67	0.000
plot_s~p	-.4574314	.18483	-2.47	0.013
plot_twi	1.901591	.98503	1.93	0.054
plot_s~m	.033503	.00577	5.81	0.000
hh_size	-2.73941	.90317	-3.03	0.002
livest~u	-4.337814	.99638	-4.35	0.000

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix 4: Average Marginal Effects after Probit (the first hurdle)

| Delta-method						
|	dy/dx	Std. Err.	z	P>|z|	[95% Conf. Interval]	
sex |	-.0151799	.0245047	-0.62	0.536	-.0632082	.0328484
age | -.	-.0017325	.000548	-3.16	0.002	-.0028066	0006584
education |	.0069655	.004698	1.48	0.138	-.0022425	.0161735
land_area |	.1537459	.0511316	3.01	0.003	.0535298	.2539621
offfarm |	.1222236	.0342035	3.57	0.000	.0551861	.1892611
dist_road |	-.001349	.0006016	-2.24	0.025	-.0025281	-.0001699
dist_market |	-.0016522	.0003157	-5.23	0.000	-.0022709	-.0010335
dist_admctr |	-.0001936	.0001401	-1.38	0.167	-.0004681	.0000809
extension |	.3687343	.011474	32.14	0.000	.3462458	.3912229
credit |	.063195	.01729	3.66	0.000	.0293073	.0970827
manure |	-.1838001	.0188956	-9.73	0.000	-.2208347	-.1467655
compost |	-.1064715	.0227273	-4.68	0.000	-.1510161	-.0619269
dist_household |	-.0047485	.0051995	-0.91	0.361	-.0149394	.0054424
soilquality_poor|	-.0616316	.021049	-2.93	0.003	-.1028869	-.0203763
plot_srtmslp |	-.0054123	.0008594	-6.30	0.000	-.0070968	-.0037278
plot_twi |	-.0048808	.0038969	-1.25	0.210	-.0125185	.0027569
plot_srtm |	.0001111	.0000205	5.41	0.000	.0000708	.0001513
agroecology |	-.0659415	.0243254	-2.71	0.007	-.1136184	-.0182647

Appendix 5

Poverty	Average land holding in hectare	Std. err.	t-value
Non-poor	.17701466	.0045877	3.9394
poor	.14111327	.0064037	
Total	.1687934	.0038446	
Difference	.0359014	.0091134	

Appendix 6

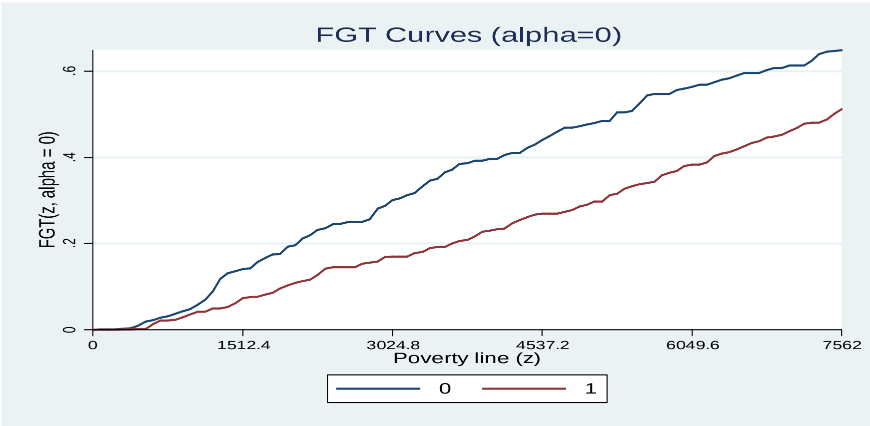
What is the reason for not using chemical fertilizers?	Freq.	Percent	Cum.
Ignorance	57	8.74	8.74
High Price	84	12.88	21.63
Lack of Money	267	40.95	62.58
Non-Availability of Supply	17	2.61	65.18
Skeptical of the Outcome	98	15.03	80.37
Other Specify	128	19.63	100.00
Total	652	100.00	

Why did you not get credit Services?	Freq.	Percent	Cum
Non-Availability of the Service	14	1.14	1.14
Unable to Pay the Loan	597	48.50	49.63
Inadequate Service Provided	164	13.32	62.96
Ignorance	27	2.19	65.15
Does Not Yield Any Results	102	8.29	73.44
Other Specify	327	26.56	100.00
Total	1.231	100.00	

Appendix 7

Do you use any manure on [Field]?	Summary of livestock tlu		t-value(diff=0)
	Mean	Std. Dev.	
No	3.7212931	2.4692197	-1.8406
Yes	3.9677777	2.5839421	
Total	3.784363	2.5006767	

Appendix 8


FGT Curves (alpha=0)
FGT(z, alpha = 0)
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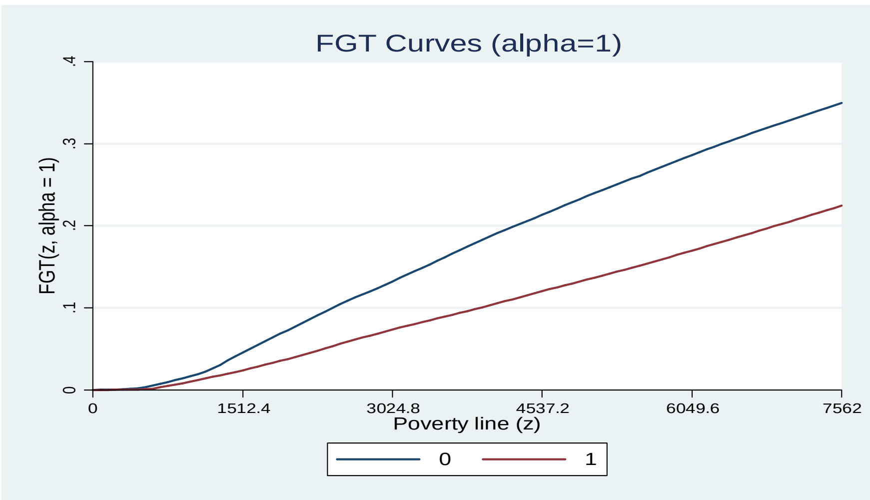
.4
.6
0
1512.4
3024.8
4537.2
6049.6
7562
Poverty line (z)
0
1


FGT Curves (alpha=1)
FGT(z, alpha = 1)
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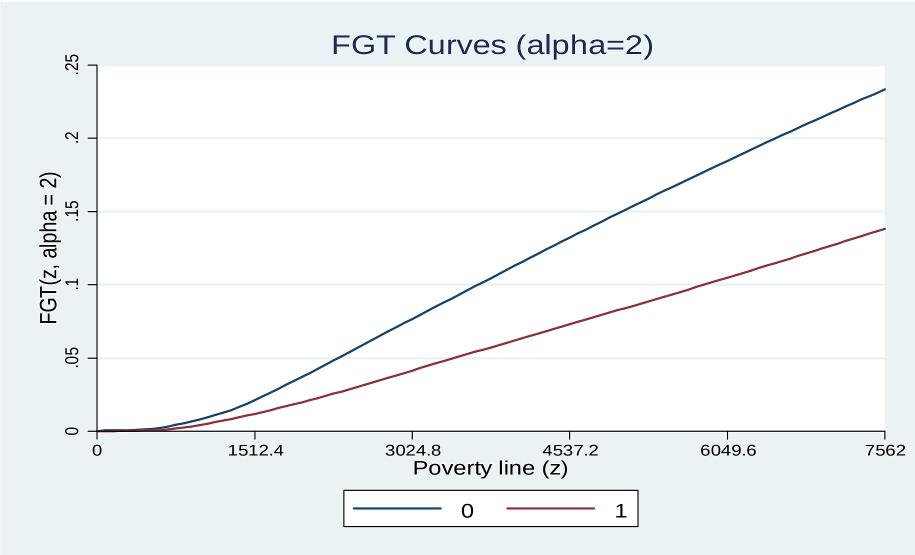
.1
.2
.3
.4
0
1512.4
3024.8
4537.2
6049.6
7562
Poverty line (z)
0
1



Appendix 9

Propensity score matching: logistic regression

Logistic regression Number of obs = 540

LR chi2(8) = 118.65

Prob> chi2 = 0.0000

Log likelihood = -310.16063 Pseudo R2 = 0.1606

chemical_f~r	Coef.	z	Std. Err.	P>|z|	[95% Conf. Interval]	
sex |	.1003654	.2817922	0.36	0.722	-.4519371	.6526679
age |	-.0108202	.006532	-1.66	0.098	-.0236227	.0019822
education |	.1993076	.0660882	3.02	0.003	.0697771	.3288382
livestock_~u |	-.0408566	.0317039	-1.29	0.198	-.102995	.0212819
area_hectar |	1.067947	.2348623	4.55	0.000	.6076256	1.528269
credit |	1.521178	.2361859	6.44	0.000	1.058262	1.984094
compost |	.4280458	.2353659	1.82	0.069	-.0332629	.8893546
manure |	.0458289	.2005118	0.23	0.819	-.3471669	.4388248
_cons |	-.3791707	.4374617	-0.87	0.386	-1.23658	.4782385

Sensitivity Analysis

rboundslnpcce. Gamma (1 (0.05) 2)

Rosenbaum bounds for lnpcce (N = 595 matched pairs)

Gamma	**sig+**	**sig-**	**t-hat+**	**t-hat-**	**CI+**	**CI-**
1	0	0	7.08643	7.08643	7.01145	7.15925
1.05	0	0	7.06713	7.10584	6.9914	7.17745
1.1	0	0	7.04853	7.12411	6.97123	7.195
1.15	0	0	7.03028	7.14136	6.9519	7.21052
1.2	0	0	7.01306	7.15818	6.93323	7.22543
1.25	0	0	6.99624	7.17346	6.91512	7.2398
1.3	0	0	6.97969	7.18745	6.89762	7.25359
1.35	0	0	6.96398	7.20129	6.88146	7.26701
1.4	0	0	6.94776	7.21384	6.86476	7.27995
1.45	0	0	6.93285	7.22579	6.84903	7.29193
1.5	0	0	6.91806	7.23743	6.83403	7.30382
1.55	0	0	6.90375	7.24874	6.81924	7.31487
1.6	0	0	6.88995	7.25992	6.80499	7.32503
1.65	0	0	6.87711	7.27006	6.79132	7.33522
1.7	0	0	6.86367	7.28074	6.77795	7.3452
1.75	0	0	6.85126	7.29039	6.76542	7.35447
1.8	0	0	6.83905	7.30011	6.75295	7.3633
1.85	0	0	6.82658	7.30933	6.74073	7.37206
1.9	0	0	6.81536	7.31782	6.72948	7.38112
1.95	0	0	6.80412	7.32571	6.71739	7.38967
2	0	0	6.79309	7.33376	6.70646	7.3977

*** gamma - log odds of differential assignment due to unobserved factors**

sig+ - upper bound significance level

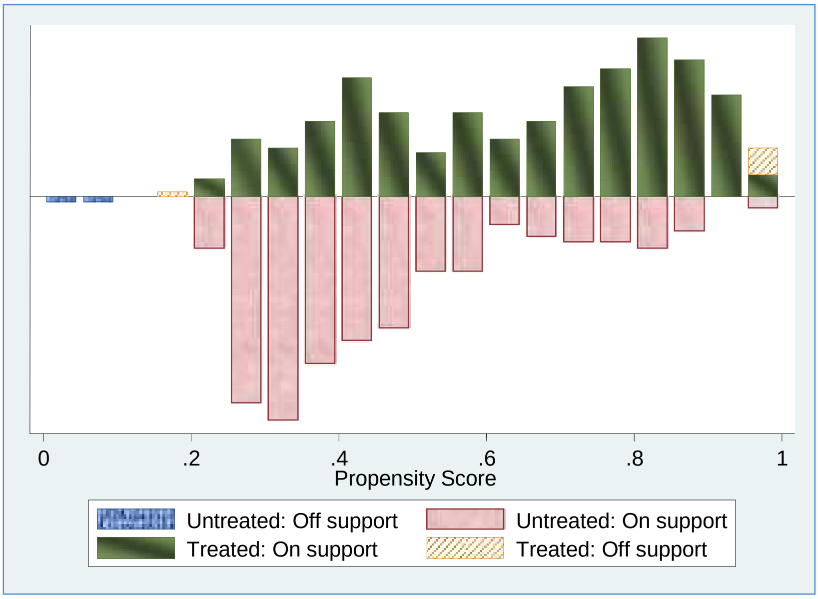
sig- - lower bound significance level

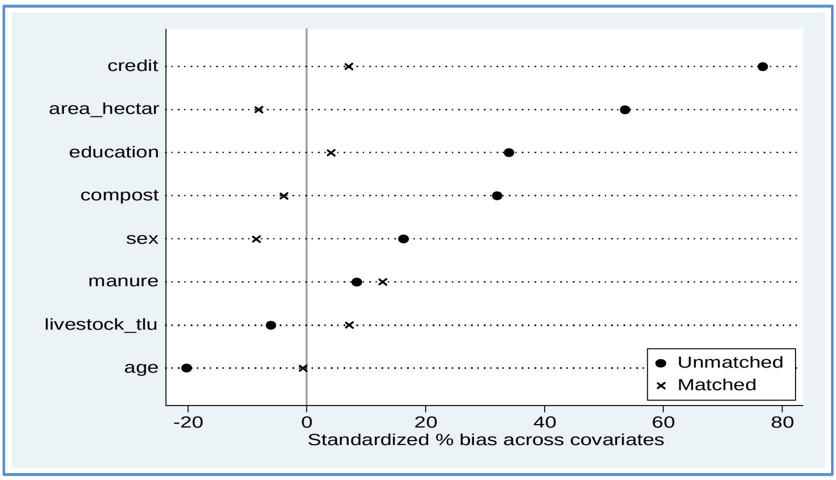
t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .95)

CI- - lower bound confidence interval (a= .95)


0
.2
.4
.6
.8
1
Propensity Score
Untreated: Off support
Untreated: On support
Treated: On support
Treated: Off support


credit
area_hectar
education
compost
sex
manure
livestock_tlu
age
Unmatched
Matched
-20
0
20
40
60
80
Standardized % bias across covariates

Analysis of Factors That Dictate Farmers to Sell Their Produces Early: Implication for Seasonal Price Fluctuation

Bedaso Taye[1]

Abstract

In Ethiopia, agricultural markets are characterized by seasonal price fluctuations as price seasonality is a fact of life in any agrarian production system. Prices of agricultural crops typically fall immediately after harvest and rise gradually thereafter until the next harvest. This study was conducted to analyze the factors that dictate farmers to sell their produces immediately after harvest and thereby create price fluctuations. The study used household survey data to estimate Tobit model for the propensity and intensity to sell crops immediately after harvest. The econometric result indicates that education of head of household, number of markets, input cost, labor cost, and credit are found to affect quantity and intensity of early sale positively while family size and technology use affect intensity and propensity to sell early negatively.

JEL Code: Q12, Q13
Key Words: Price Fluctuation, Tobit Model, Crop markets, Early Selling

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1. Introduction

Agriculture in Ethiopia is practiced mainly by farmers that rely on small scale production. Crop production and marketing are the means of livelihood for millions of households in the country. It is the single largest sub-sector within Ethiopia's agriculture, far exceeding all others in terms of its share in rural employment, agricultural land use, calorie provision, and contribution to national income. For example crop production contributed 68.3% to agricultural GDP and 26.1% to total GDP of the country in 2013/14 (MoFED, 2014)). This indicates that a shock in this sub sector affects the economy significantly.

There are several factors that affect the productivity of the sector, dependence on rainfall and limited adoption of improved technologies being the major ones. Apart from these problems, failure to secure sustainable and profitable grain markets constrain the development of the sector and prevent farmers from benefiting adequately from their harvests.

The majority of farmers use local or town markets to sell their produce. A recent survey by Sasakawa Global 2000 on smallholder farmers' market access indicates that more than 90 percent of farmers in Ethiopia use local and town markets that are not large enough to accommodate all surplus production (SG 2000, 2012)). Due to such narrow and undiversified markets, farmers are vulnerable to acute price falls during peak harvest times. The problem gets worse in areas where perishable and non-storable crops are produced in bulk.

In theory price fluctuations should benefit the producer, but in practice the result might be different if risk awareness is not considered. For developing countries it might be even more important to reduce the risk of price fluctuations due to the relative importance of agricultural food products (Bäckman and Sumelius, 2009). Therefore, it is worthwhile to understand the causes of price fluctuations and take appropriate policy measures to curb them.

The major reasons behind price fluctuations are related to demand, supply and market institutions (Bäckman and Sumelius, 2009). While it is plain to argue that prices change with changes in demand, it is also fair to argue that demand factors are stable and gradual unlike supply factors. Changes in supply are usually unpredictable and large enough to create huge price fluctuations. Higher market supplies will push prices down if there is no corresponding change in demand particularly during peak harvest times of agricultural products. Some of the reasons why households sell their produce too early are to pay for household events inputs in addition to the fact that their produce and farm labor costs might be perishable (SG 2000, 2012). Moreover, household cash demand dictates farmers to sell their produce immediately after harvest. Due to these reasons farmers tend to bring their produce to market places immediately after harvest which increases supply temporarily and push prices down. This prevents farmers from adequately benefiting from their harvests.

The grain marketing system and the spatial movements of Ethiopian grain prices have been widely studied (Getnet, 2007; Getnet *et al*., 2005; Negassa, 1998; Negassa *et al*., 2004; Tadesse, Shively, 2009, Shahidur *et. al*., 2010/11 and Getaw *et al*., 2010). However, they hardly assessed the factors that lead farmers to sell their harvests too early, which cause abnormal seasonality of prices. Most of them are based on analysis of factors that influence commercialization, outlet choice, and price trends and marketing margins over times and storage decisions. Particularly Getaw *et al*., 2010, analyzed the behavior of commodity prices and economics of storage using time series data but without analyzing quantity sold and temporal selling decisions. Therefore, there is a missing link in these studies to explain why farmers sell their produces too early and create temporary market gluts that reduce significantly the price that farmers receive. Based on this fact this study tries to identify and explain factors that dictate farmers to sell their production too early. The specific objectives of the study are to:

1. estimate the quantity of crop outputs sold immediately after harvests, and

2. identify and explain factors that dictate farmers to sell their produce too early and intensity of early sales.

2. Nature of Crop Markets in Ethiopia

Assessment of market performance requires analyses of prices (over time and space) and the process that influences price formation. This follows from the simple fact that the price of a commodity is the outcome of an exchange process, which we call the market. In the absence of public interventions, three important determinants of an efficient exchange process (market fundamentals) are infrastructure, institutions, and information (Rashid and Asfaw, 2011). If there is inadequacies/incompleteness in these fundamentals, it will be reflected in the prices. For instance, if the markets are not connected with adequate infrastructure and efficient information flow, price shocks in one market location may not get transmitted to the other, which can be detected through spatial integration of market locations (*ibid*, pp 17). Similarly, if farmers do not have access to credit or risk-mitigating institutions, they are compelled to sell immediately after harvest when prices are low. The presence of such institutional incompleteness can be detected though analysis of price seasonality and its causes.

Seasonality is a fact of life in any agrarian production system. Prices of agricultural crops typically fall immediately after harvest and rise gradually thereafter until the next harvest. This is a natural price pattern, unless prices fall too low after the harvest or rise too high during the lean season. In a competitive market, the difference between harvest time and lean season prices should reflect the costs of storage, which consist of opportunity costs of holding stocks (interest charges), storage losses, the costs of labor and capital, and a normal profit (Timmer *et.al*., 1983). While concluding whether seasonality is consistent with competitive markets is difficult, any changes in price seasonality should indicate an improvement (or deterioration) of market performance. An improvement in access to credit can alleviate farmers' liquidity constraints and hence reduce distress sale and market supply, resulting in an overall increase in postharvest prices. Similarly, improved storage and access to credit can lower the cost of storage and hence result in lower lean season prices.

Furthermore, contrary to the common perception that the seasonality of grain markets are changing, seasonal variations in prices tend to follow the country's production cycles (Rashid and Asfaw, 2011). This indicates that prices of agricultural products fall during peak harvest seasons and rise in lean seasons.

Shahidur and Moron, 2010 analyzed the cause of price instability in Ethiopia with a focus on staple food crops. They mentioned three factors as the main source of price instability. These are agro-climatic factors, information and infrastructure, and incomplete markets: insurance and credit, and other factors (like world food prices and high safety net interventions). It seems that due to over dependence on rainfall, agricultural production in Ethiopia is seasonal which involves a huge supply in times of harvest and little in off seasons. Even though infrastructure and access to information are recently being improved, a vast majority of Ethiopian farmers live in conditions of limited infrastructure and access to information. Therefore, this has an adverse effect on price information in the country.

The undeveloped and incomplete credit and insurance markets in Ethiopia are the other factors that create price volatility in the country (Shahidur and Moron, 2010). In developing countries, these institutions are largely incomplete or non-functional, and thus inadequate to address the credit and insurance needs of a vast majority of households (Shahidur and Moron, 2010). This indirectly contributes to agricultural risks and price instability. For instance, if the credit market is well-functioning, households can borrow to maintain a certain level of consumption, or to avoid distress sales in the face of negative income shocks. It is often the case in many developing countries where farmers have to sell a portion of their crops immediately after harvest to pay loans, wages, school fees, or to meet other social obligations.

3. Seasonal Fluctuation of Price of Major Crops in Ethiopia

In Ethiopia seasonal price fluctuations are not studied widely. Most studies focus on the 2007/08 price hike and related developments. For example, Shahidur (2010) explained the reasons behind price trend puzzles in Ethiopia. He emphasized three key factors behind unusual food prices in Ethiopia. The first factor was that the growth in money supply far exceeded the overall economic growth in the country. This clearly implies strong inflationary pressure. Indeed, a 2007 World Bank study argued that, during 2004-2006, the money supply increased by 108 percent, and real GDP increased by 48 percent. That is, growth of the money supply was 40 percent faster than the GDP growth. This helps explain the growth in nominal food prices over this period. The real price of most cereals, except *Teff*, actually declined during that time (World Bank, 2007 as cited in Shahidur, 2010).

Another most important factor behind this puzzling price trend appears to be an over-estimation of cereal production. The price trend in 2007-2008 was indeed puzzling because prices were going up despite a reported growth of about 15 percent in cereal production. Compare this with 2002- 03, when a reported bumper harvest of 9 million tons of grain resulted in market collapse—so much so that some farmers did not find it worthwhile harvesting their maize (Shahidur, 2010). The International Food Policy Research Institute and the Joint Research Centre of the European Union conducted a comprehensive study in order to better understand the puzzling trends. The study involved a representative household survey, a market survey, a cross border trade survey, as well analyses of a large amount of time series data. One of the key findings of the study was that production estimates of cereals from the IFPRI survey were roughly 30 percent lower than the official estimates (Minot, 2008 cited in Shahidur, 2010).

When we look at monthly (seasonal price variation), for most crops prices during the months of December, January and February are lower than other months. For example average wholesale price of maize in 2011/12 for these months was 10percent lower than average whole sale prices of other months.

Similarly, average whole sale prices of wheat and *Teff* was lower during the peak harvest seasons than the lean seasons. Look at the graphs below to see the behavior of prices over months in 2011/12 and 2012/13.

Figure 1: Monthly average wholesale price of *Tiff* in Amhara and Oromiya regions 2011/12-2012/13

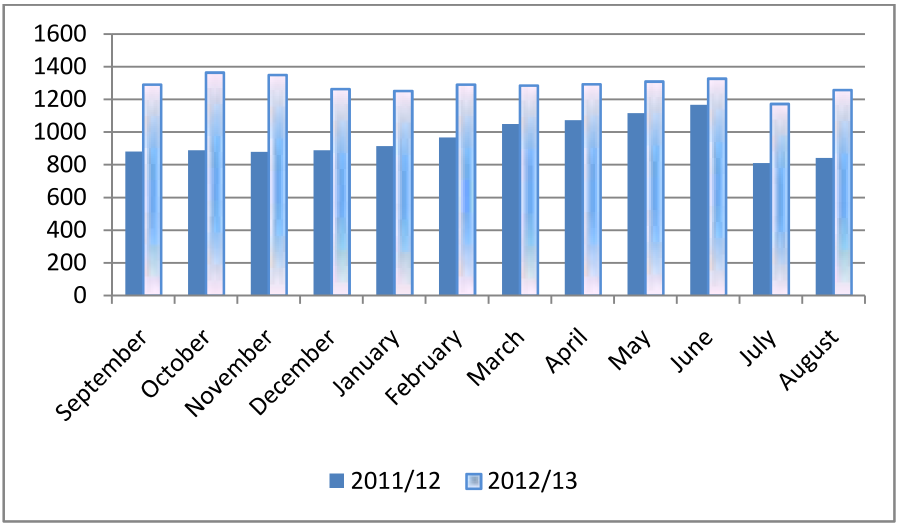
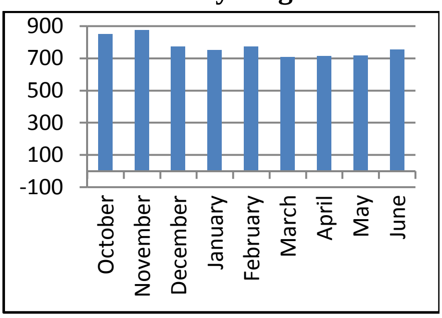
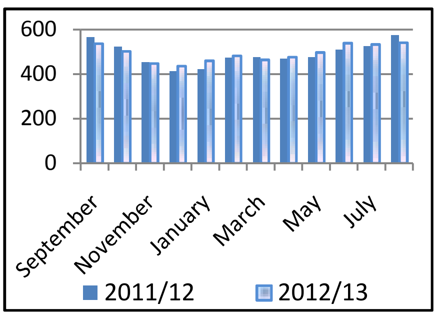


Figure 2: Monthly average wholesale price of maize in Amhara and Oromiya regions 2011/12-2012/13



Monthly average wholesale price of wheat in Amhara region



Monthly average wholesale price of maize in Oromia

Source: Computed from EGTE data (2011/12)

4. Methodology of the Study

The study is based on a household survey conducted using structured instruments to collect data from randomly selected 845 agricultural households in 14[2] Woredas of Oromia, Amhara and SNNP regions in December 2011. 35-40 households per Keble were randomly selected based on systematic sampling methods using a list of household names at Kebeles as a sampling frame. The Woredas are mostly mid-highland and highland known for surplus production in the country. They include Adana, Arsis Robe, Tale, Chewbacca, Gules, Beret in Oromia region; Deben, Arable, Dangle, LiboKemkem and DawaCheffa in Amhara region and, Cheha, Lemmo and Silti in SNNP region. The data consists of household characteristics, agricultural production, post-harvest activities and post-harvest losses, market access, technology and extension service use, credit access and marketing infrastructure and problems. In order to assess and triangulate the general agricultural activities of the communities including community level technology adoption and the institutional environment the survey was also conducted at Woreda and Kebele levels.

The data is analyzed using descriptive statistics and an econometric framework to identify the factors that affect intensity and propensity to sell crop outputs immediately after harvest. The quantity sold too early and its effect on price is analyzed descriptively.

4.1 Specification of the Model

In this study the major focus is to see the factors that affect farmers to sell their products too early and the amount they sell early. The econometric model applied for analyzing factors influencing participation and intensity of participation in certain activities is the Tobit model shown in equation (1). This model is chosen because it has an advantage over other models (LPM, Logistic, and Probit) in that it reveals both the probability of participation of

[2] 2 kebeles per Woreda were selected for Woredas where control group are included and only one kebele per Woreda where control group is not included.

farmers in early sale and intensity of their sale. Following Maddala (1992), Amemiya (1985) and Johnston and Dinardo (1997), the Tobit model can be defined as;

$$Yi * = \beta Xi + \varepsilon_i i = 1, 2 \ldots n \qquad \textbf{(1)}$$

$$Yi = Yi^* \text{ if } Yi * > 0$$
$$= 0 \text{ if } Yi * < 0$$

Where,

Yi = the observed dependent variable, in our case the quantity of output sold within four weeks after harvest. Y_i^*= the latent variable which is not observable. Xi is vector of factors affecting farmers' decision to sell within four weeks after harvest and β is vector of unknown parameters to be estimated while ε_i is residual that is independently and normally distributed with mean zero and a common variance δ^2. Note that the threshold value in the above model is zero. This is not a very restrictive assumption, because the threshold value can be set to zero or assumed to be any known or unknown value (Amemiya, 1985). The Tobit model shown above is also called a censored regression model because it is possible to view the problem as one where observations of Y* at or below zero are censored (Johnston and Dinardo, 1997). The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997 and Amemiya, 1985).

$$L = \prod_{yi^*>0} \frac{1}{\sigma} f\left(\frac{Y_i - \beta i X i}{\sigma}\right) \qquad \textbf{(2)}$$

Where L and F are respectively, the density function and cumulative distribution function of $\prod_{yi*}$ means the product over those i for which Yi*>0, and $\prod_{Yi*}$ means the product over those i for which Y>0.

It may not be sensible to interpret the coefficients of a Tobit in the same way as one interprets coefficients in an uncensored linear model (Johnston and Dinardo, 1997). Hence, one has to compute the derivatives of the estimated

Tobit model to predict the effects of changes in the exogenous variables. As cited in Maddala (1997), Johnston and Dinardo (1997), McDonald and Moffit proposed the following techniques to decompose the effects of explanatory variables into participation and intensity effects. Thus, a change in Xi (explanatory variables) has two effects. It affects the conditional mean of Yi in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. A similar approach is used in this study. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(Yi/Yi^{*}>0)}{\partial Xi} = \beta i\left[1 - Z\frac{f(Z)}{F(Z)} - \left(\frac{f(z)}{F(Z)}\right)^{2}\right] \quad \textbf{(3)}$$

Where, (2) is denoted by z, following Maddala, (1997). The Change in the probability of selling crop outputs as independent variable Xi changes is:

$$\frac{\partial E(Y_i)}{\partial X_i} = F(Z)\beta i \quad \textbf{(4)}$$

The change in intensity of participation with respect to a change in an explanatory variable among participants is:

$$\frac{\partial E(Y_i/Yi*>0)}{\partial X_i} = F(Z)\beta i \quad \textbf{(5)}$$

Where, F (z) is the cumulative normal distribution of Z, f(z) is the value of the derivative of the normal curve at a given point (i.e., unit normal density), Z is the z-score for the area under normal curve, βis a vector of Tobit maximum likelihood estimates.

4.1.1 Description of Explanatory Variables

A. Dependent variable

Quantity of output sold within four weeks after harvest (Q_S): It is a partially continuous variable of quantity of crop output sold within four weeks after harvest. It takes positive the value Qs if the household sold crop output within four weeks after harvest and takes the value of zero otherwise. So it is left censored variable at 0. Since most perishable crops like vegetables are sold immediately after harvest the study only included grain crops (cereals, pulses and oil crops).

B. Independent variables

1. **Sex:** a dummy variable representing sex of household head; 1 if male, 0 if female. Since male headed households are better off in both production and asset endowment, it is expected to have a negative relationship with quantity sold early.
2. **Education:** A continuous variable indicating educational level of household head. It is assumed that more educated household heads have a lower tendency to sell their products too early.
3. **Asset value:** A continuous variable representing the estimated asset value of the households. Since it represents the asset endowment of the household it is expected to reduce quantity of output sold early after harvest.
4. **Family size:** A continuous variable representing the size of the family of the household. This may have either a negative or positive sign depending on whether the household members are earners of income or dependent. To capture age, factor adult equivalent family size is used in this study.
5. **Labor cost:** This is a continuous variable indicating the estimated labor cost incurred by the household in the production of crops. Since it reduces the effect of heteroscedasticity, log of labor cost is considered in the estimation.
6. **Cost of inputs:** The higher the cost of inputs incurred by households in the last production season the higher the demand for cash after harvest and hence the probability to sell early is higher. Log of input cost is considered in the estimation for this variable too.
7. **Storage method:** A dummy variable of the type of storage materials for crop outputs. Households with improved storage

facilities are expected to sell outputs later when prices are higher and stable; hence storage dummy is hypothesized to affect quantity sold within four weeks after harvest negatively.

8. **Non-farm income:** A dummy variable to see whether the household has a non-farm income source. If households have alternative income sources they can defer sale of crop output to a time of good prices.
9. **Market information:** This is A dummy variable which takes T HEvalue of 1 if the household received market information or received training on output marketing and 0 if not. Farmers who have information and training on output marketing are expected to make prudent decisions and hence the expected sign for market information variable is negative.
10. **Credit/Debt:** This is a dummy variable for a household that took loans (credit) the previous year. If households are expected to repay loans after harvest, they are forced to sell their products after harvest immediately.
11. **Extension:** A dummy variable that takes 1 if the household has received extension service in the production year or 0 otherwise. Since extension is expected to deliver both production and marketing information this variable is expected to reduce early sale.
12. **Technology:** A dummy variable that takes 1 if a household used improved technology (seed, full rate of fertilizer etc.) or 0 otherwise. Since farmers that use improved technologies are supposed to be informed farmers this variable is expected to reduce early sale.

5. Findings and Discussion

5.1 Household Characteristics

The data used covered 3 regions, 14 Woredas and 21 Kebeles and 805 households. About 71percent of the households are male headed and 29 percent female headed. Average family size is 5.84 and dependency ratio is 1.37 persons per adult. 69.8percent of the heads are married and monogamous, and 19.8 percent are widowers. About 93percent of the households rely on agriculture and a smaller proportion of households is engaged in non-farm activities like casual labor (14.7percent) beverage sale (5percent) and farm product trading (22percent). It was also found that 45percent of the household heads cannot read and write while 15percent of them have attended only informal education. 33.8percent of the heads have completed primary education and only 5.8percent of them have completed post primary education.

All households have about three building structures in their homestead on average. However, the building materials are mostly traditional. For example 45percent of the roofs of their living houses are made of thatch and straw and 55 percent corrugated iron tin. 91.7 percent of the walls of living houses are constructed out of mud while 98.2 percent of the floors are made of earth or mud. About 40percent of the households have separate bed rooms, and 59.5percent and 58.8percent of the households have kitchens and toilets, respectively. On average each household has an estimated asset value of 2291 ETB. Households in Oromia have higher estimated asset value than the other two regions. Land is another important asset held by farming households. In this survey each household has 1.62 hectares of land and each operates on 1.92 hectares of land. The main means of access to land include; allocation by government (50.6percent), renting (10.5percent) and inheritance (25.8percent).

Almost all (97percent) households are engaged in crop production as their primary livelihood source. Livestock production is a secondary source serving 72percent of the households. Trading crop and livestock products and petty trade are tertiary sources of income for 17.6percent and 10.4percent of the households, respectively. Female headed households participate more in nonfarm activities like off farm labor (4.3percent) and petty trade (3.9percent). The most common off farm income sources are alcohol trading absorbing 15.7percent of the households, and off farm labor, handicraft and trading grains which, in this order, engage 15percent, 12.6percent and 12.2percent of the households. In 2010, households received

1533 ETB average income from all off-farm activities with households in SNNP receiving 2296 ETB average annual income. Those households engaged in wage earning employment and alcohol trading received more income than in other activities. On the other hand, 13percent of the households had bank accounts in 2010 and the proportion of households that received credit in the same year was 44.3 percent. The main sources of credit in Oromia are Saving and Credit Cooperatives (SACCOs) and Microfinance Institutions (MFIs) while it is service cooperatives and MFIs in Amhara and government and relatives in SNNP Region.

5.2 Quantity produced and sold by households

Teff, maize and wheat are cultivated by 71%, 61% and 46%, respectively, of the households covered by the study. All crops covered 1387 hectares of cultivated land out of which *Teff*, maize, wheat, sorghum and chick pea took 100.81ha (72.29percent. *Teff*, maize, wheat, chickpea, sorghum, finger millet, vetch (grass pea), rice, barley and faba bean are the top ten crops grown. In the 2010/11 production season, sample households harvested 16,471 quintals (1647.1 tons) of crops of which *Teff*, wheat and maize constituted 65percent. Therefore, *Teff*, maize and wheat are the top three crops in terms of area, production and number of cultivating households.

With regard to yield, on average 10.91 quintals of *Teff* were harvested from a hectare while maize and wheat yields were 21.62 Qt/ha and 15.51 Qt/ha, respectively. Yields of *Teff* and maize are the highest in Oromia with (12.49Qt/ha and 22.61Qt/ha, respectively) and the lowest in the SNNP with (9.71 Qt/ha and 19.12Qt/ha) in that order. In 2011 most of the harvest was used for consumption. As the data indicates 43percent of the total harvest was consumed and 29 percent was sold while the remaining was used as seed, animal feed and giveaway.

Table 1: Quantity harvested, total quantity sold and sold within 4 weeks of harvest

Region	Total quantity harvested (Qt)	Total quantity sold (Qt)	Quantity sold within 4 weeks (Qt)	Percent of total quantity sold	Percent Quantity sold within 4 weeks	Percent of Total quantity sold within 4 weeks of harvest
Oromia	11,358.4	3,776.5	524.1	33.2%	13.9%	4.6%
Amhara	7,297.5	1,833.0	314.9	25.1%	17.2%	4.3%
SNNP	1,302.8	169.6	45.9	13.0%	27.1%	3.5%
Total	**19,958.6**	**5,779.1**	**885.0**	**29.0%**	**15.3%**	**4.4%**

Source: baseline survey of SG 2000 – Ethiopia, December 2011

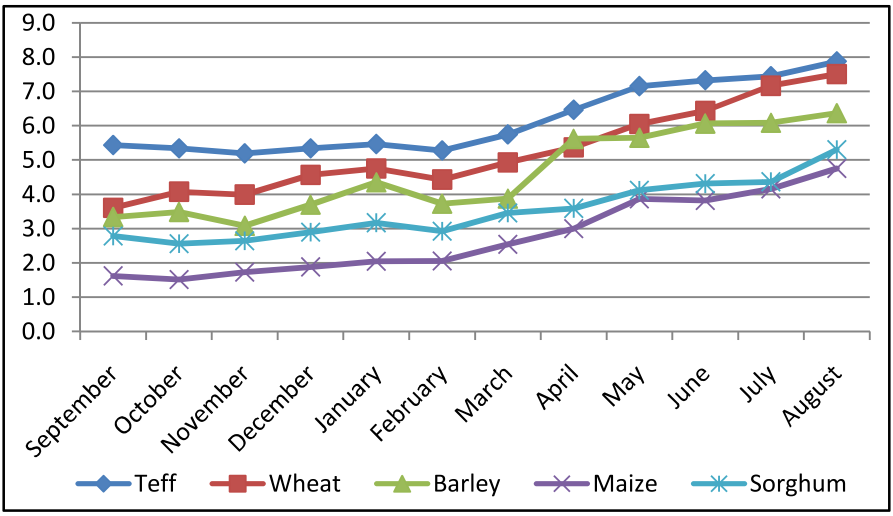
As the table above reveals, out of the total quantity produced 29 percent was sold by households in the year and 15.3percent of the total quantity sold was sold immediately after harvest. Of the total harvest the quantity sold within four weeks constitutes about 4.4percent. A simple analysis indicates that if households delayed the sale for at least eight weeks they would get an additional 439 Birr income. This is because after two months of harvest, the average price of grains increase by 7.6 percent. Price fluctuation is the main marketing problem reported by 67.8percent of the households surveyed. Lack of transportation and long distance to the market places are the other market access problems each reported by 22.8percent of the households. The main reason behind price fluctuation and low prices during harvest is lack of enough market centers in the Regions and seasonality in the supply of products. There is a small number of buyers and the marketing options are limited so that prices go down during peak harvest time. About 44 percent of the households sold at least one of their products within four weeks of harvest due to various reasons.

The main reasons why households sell their crops within four weeks of harvest are: to pay for household functions, like wedding, *mahiber* etc. which was reported by 53.6percent of the households; due to perishable nature of the products reported by 26.5percent; and to pay for farm labor cost, reported by 18.4percent of the households. In the SNNP Region households that reported "perishable nature of the products" as their main reason constitute the highest category (66.2percent), while in Oromia it is farm labor cost which accounts for 34.5percent and household functions in Amhara accounting for 74.5percent.

5.3 Price Variations of Major Crops

Price for food grain is more volatile than non-food items (FAO, 2008). This is because of the non-elastic demand for food items and the variation of supply across time. CSA data shows that prices of major food crops is higher in the months of June-November after which they show a steady decline until they start to rise again after May. These months (November to May) correspond with the major harvest season of the country. The average producer price of *Teff* from September to November in 2005 E.C was 11.78 Birr per kg, which fell to 10.92 Birr per kg in the subsequent three months (December to February).

Figure 3: Price of major food crops



Source: CSA producer price survey, 2003 E.C

5.4 Econometric Results

The study applied the Tobit model to estimate factors that dictate farmers to sell their outputs immediately after harvest. During the survey 508 households did not sell their harvest within 4 weeks and hence they were left censored. The likelihood ratio chi-square of 99.35 (*df*=17) with a p-value of 0.0000 tells us that the model as a whole fits significantly better than an empty model (i.e., a model with no predictors). Model estimates show that the model is robust as the overall p-value is 0. The log likelihood and pseudo $R^2$are found to be -1073.5958 and 0.0442, respectively.

In general the estimation exercise indicates that technology use, education level, number of markets, input cost, labor cost, credit, family size and regional dummies are found to significantly affect quantity sold within 4 weeks of harvest.

In addition to determinants of quantity sold within four weeks, the model estimates determinants of early sale. According to H. Joseph Newton (2000) for the Tobit model, there are four forms of marginal effects that are of great interest. They are (1) the β coefficients themselves are the changes in the mean of the latent dependent variable, (2) the changes in the unconditional expected value of the observed dependent variable, (3) the changes in the conditional expected value of the dependent variable, (4) the changes in the probability of being uncensored. The above estimates are the β coefficients that affect the change in mean of the dependent variable, i.e. quantity sold within four weeks of harvest. In this study the 4^{th} marginal effect is one of our interests. That is the probability of being censored or probability of selling within four weeks. In what follows we discuss the conditional marginal effects and probability of being censored. In other words we discuss the marginal effect of the independent variables given that the quantity sold early is greater than zero and the variables that affect the probability of selling too early.

Table 2: Tobit estimates of determinants of quantity sold within four weeks

Variables	Coef.	Std. Err.	t-value	P>t	[95% Conf. Interval]	
Technology	-1.864	0.8968	-2.08	0.038	-3.625	-0.104
Extension	0.370	0.8140	0.45	0.650	-1.228	1.968
Education	-0.259	0.1205	-2.15	0.032	-0.496	-0.023
Number of markets	0.592	0.3387	1.75	0.081	-0.073	1.257
Market info	-0.348	0.7780	-0.45	0.655	-1.875	1.179
Lnassets	0.197	0.3460	0.57	0.568	-0.482	0.877
Lninputc	1.416	0.3801	3.73	0.000	0.670	2.163
Lnlaborc	0.221	0.1246	1.77	0.077	-0.024	0.466
Oromia_dummy	4.592	1.2319	3.73	0.000	2.174	7.010
Amhara_dummy	5.256	1.2471	4.21	0.000	2.808	7.704
Storage method	0.482	0.4248	1.14	0.256	-0.351	1.316
Improved seed	0.000	0.0044	0.06	0.956	-0.008	0.009
Land size	0.314	0.3457	0.91	0.364	-0.365	0.993
Sex of head	0.853	0.8351	1.02	0.307	-0.786	2.493
Credit received	1.310	0.6851	1.91	0.056	-0.035	2.655
Adult Equivalent	-0.311	0.1825	-1.7	0.089	-0.669	0.047
Non-farm income	-0.202	0.6859	-0.29	0.769	-1.548	1.145
_cons	-22.194	3.2021	-6.93	0.000	-28.480	-15.907
/sigma	***7.09493***	***0.33982***			***6.428***	***7.762***

Obs. summary: 508 left-censored observations at Quantity sold in 4wks<=0
254 uncensored observations
0 right-censored observations

Table 3 below gives the conditional marginal effects of the variables on quantity sold within four weeks of harvest. For example farmers that used improved technologies sold 0.54 quintals less of their output within four weeks. This can be because farmers that use improved technologies have better access to information and make profitable marketing decisions. Similarly as farmers' level of education increases by 1 year quantity sold within four weeks decreases by 0.26 quintals.

One of the variables that affect the level of output sold is access to markets. In this study, number of markets in the area, market information and distance to markets are used as indicators of market access. From these variables the number of market places (sales outlets) is found to positively and significantly affect quantity sold within four weeks of harvest. Additional number of market places in the Woreda increases quantity sold within four weeks of harvest by 0.17 quintals.

In rural Ethiopia the most common factors that dictate farmers to sell their products too early are demand to pay loans, family expenditure, labor costs, non-availability of assets or income and perishability lack of/storage facility. To see the impacts of these variables the study included input cost, labor cost, assets value, availability of improved storage facilities and credit. All these variables, except asset value and storage facilities are found to significantly affect quantity sold too early. For example, one unit increase in cost of inputs increases quantity sold by 0.4 percent, other things remaining constant. In addition to this a unit increase in cost of labor increases quantity sold too early by 0.06 percent. This is because farmers that incur higher cost of inputs and labor face higher demand for cash earlier than others. Moreover, it is good to be cautious in using this result because farmers that spent higher cost of inputs may be market oriented/commercial farmers that produced outputs for selling purpose only. In this study adult equivalent is included to capture labor size of households. As highlighted in the methodological section this variable can have either a negative or positive effect. The estimation shows that as family size increases by one unit quantity sold too early is reduced by 0.09 quintal. The reason can be that adult equivalent, unlike family size, captures number of economically active household members who can contribute to household income. The higher the number of adult equivalent in a household the less the demand for hired labor which eases pressure to sell outputs too early for cash.

One of the key factors that dictate farmers to sell their output too early is indebtedness. Therefore, the study included information on whether or not the farmers have received credit in that production season. Accordingly, the result indicates that farmers that received credit (owe money to others) sold 0.38 quintals more output than farmers who did not receive credits. This justifies that Ethiopian farmers sell a significant amount of their outputs at lower prices during peak harvest time to pay for credits. Therefore, credit interventions should take into account this effect when deciding the appropriate time for loan repayment by farmers.

Table 3: Conditional marginal effects of variables

Variables	dy/dx	Std. Err.	z-value	P>z	[95% Conf. Interval]	
Technology	-0.544	0.263	-2.07	0.038	-1.059	-0.030
Extension	0.108	0.238	0.45	0.650	-0.358	0.574
Education	-0.076	0.035	-2.14	0.032	-0.145	-0.007
Number of markets	0.173	0.099	1.74	0.081	-0.022	0.367
Market info	-0.102	0.227	-0.45	0.655	-0.547	0.344
Lnassets	0.058	0.101	0.57	0.569	-0.141	0.256
Lninputc	0.413	0.113	3.68	0.000	0.193	0.634
Lnlaborc	0.064	0.036	1.77	0.077	-0.007	0.136
Oromia_dummy	1.341	0.365	3.68	0.000	0.626	2.055
Amhara_dummy	1.534	0.370	4.15	0.000	0.810	2.259
Storage method	0.141	0.124	1.13	0.257	-0.102	0.384
Improved seed	0.000	0.001	0.06	0.956	-0.002	0.003
Land size	0.092	0.101	0.91	0.363	-0.106	0.289
Sex of head	0.249	0.244	1.02	0.308	-0.230	0.728
Credit received	0.382	0.200	1.91	0.056	-0.010	0.775
Adult Equivalent	-0.091	0.053	-1.70	0.089	-0.196	0.014
Non-farm income	-0.059	0.200	-0.29	0.769	-0.451	0.334

Another important point is that the two regional dummies have been found to affect quantity sold within four weeks significantly. This means farmers in Oromia and Amhara regions sell more outputs too early than farmers in SNNP region. The reason for this might be that farmers in SNNP have more non-farm income to take care of immediate expenses. The quantity of output produced and sold in the year is also lower than in the other regions. It also worth noting that important variables like using extension service, head of household were found to be insignificant determinants of early sale.

In addition to estimates of marginal effects of variables, estimates of the probability to sell outputs too early are given in Table 3. The same variables that affect the conditions for expected value of output sold too early affect the probability of early sale. Therefore, farmers that use improved technologies have eight percent less probability to sell outputs too early. Similarly, as years of education of head of household increases by one year the probability to sell outputs too early decreases by 1.1 percent which is significant at the level of 5 percent.

Table 4: Marginal effects of probability of selling outputs too early

Variables	dy/dx	Std. Err.	z-value	P>z	[95% Conf. Interval]	
Technology	-0.081	0.039	-2.1	0.036	-0.157	-0.005
Extension	0.016	0.036	0.45	0.650	-0.053	0.086
Education	-0.011	0.005	-2.17	0.030	-0.022	-0.001
Number of markets	0.026	0.015	1.76	0.079	-0.003	0.055
Market info	-0.015	0.034	-0.45	0.655	-0.082	0.051
Lnassets	0.009	0.015	0.57	0.569	-0.021	0.038
Lninputc	0.062	0.016	3.83	0.000	0.030	0.093
Lnlaborc	0.010	0.005	1.78	0.075	-0.001	0.020
Oromia_dummy	0.200	0.052	3.83	0.000	0.098	0.303
Amhara_dummy	0.229	0.052	4.38	0.000	0.127	0.332
Storage method	0.021	0.018	1.14	0.255	-0.015	0.057
Improved seed	0.000	0.000	0.06	0.956	0.000	0.000
Land size	0.014	0.015	0.91	0.362	-0.016	0.043
Sex of head	0.037	0.036	1.02	0.307	-0.034	0.109
Credit received	0.057	0.030	1.93	0.054	-0.001	0.115
Adult Equivalent	-0.014	0.008	-1.71	0.087	-0.029	0.002
Non-farm income	-0.009	0.030	-0.29	0.769	-0.067	0.050

Other things remaining constant, number of markets in a particular area increases the probability to sell outputs too early. The data shows that as number of market centers increases by one the probability to sell outputs too early increases by 2.5 percent which is statistically significant at the level of 10 percent. Moreover, cost of inputs and labor also increase the probability of selling outputs early. As cost of labor and inputs increases by one unit, the probability to sell output early increases by 6.2 percent and 1 percent, respectively.

The other variables that affect the probability to sell early are credit and adult equivalent family size. Those farmers who received credit had a 5.7 percent higher probability to sell their crops too early. A unit increase in adult equivalent family size reduces the probability to sell crops early by 1.4percent and the estimate is significant at 10percent significance level.

6. Conclusion and Policy Implication

The study analyzed factors that dictate farmers to sell their crops too early. It is done using the Tobit model that enable us to identify both the factors that affect probability to sell early and intensity of sale. It is observed in the study that there is a significant amount of output that sold too early (within 4 weeks after harvest) which is up to 5 percent of total harvest. This pushes the local price down and farmers sell their output at lower prices to only buy it back at times of higher prices. Due to limited local market size and huge simultaneous supply there is a strong downward effect on price of agricultural products. For example the price of agricultural output is reduced by up to 10percent during a harvesting season, despite an upward trend of price over time. After the peak time of harvest prices gradually increase. If farmers delayed sale of their outputs for three months after harvest in 2012, their sales revenue would have increased by about 439 Birr because price of output increased by 7.6percent at that time in 2003 E.C.

Some of the factors that identified to affect the propensity and intensity to sell output too early are use of improved technology, educational level of head, of household adult equivalent family size, credit, number of local markets, cost of labor and inputs and regional dummies. However, access to extension services, market information, land size and asset holding are found to be non-significant factors in determining selling crops too early. Therefore, there is a need to improve farmers' access to technology and improve credit management system, particularly repayment time. Previous studies indicated that access to credit is important to avoid early sale of outputs. However, in this study the farmers who received credit are found to sell too early than others. This is because credit is given for production not for marketing. A credit facility for crop marketing is one of the intervention areas to avoid sale of hard earned outputs at lower prices.

Moreover, crop price insurance can be one of the solutions to avoid too early sale of crops at lower prices. Farm households face different types of compulsory expenditures immediately after harvest. Some of the compulsory expenditures are loan repayment, school fees and wages for hired labor which are unavoidable. In order to effect these payments without selling outputs at lower prices, marketing insurance can be an important scheme for farmers.

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Annex

Table 5: Description of dependent and independent variables

Variable name	Description of the variable	N	Mean	Standard division	Minimum	Maximum
Q_sold4wks	Quantity of output sold within 4 weeks after harvest in quintals	790	1.14	3.82	0	70.5
Age	Age of household head in years	790	45.43	13.65	20	99
Sex	Sex of head, 1=male, 0= female	790	0.71	0.45	0	1
Land size	Land owned in ha	787	1.50	1.34	0.0075	15.25
Improved seed	Quantity of improved seed used	790	27.57	79.84	0	1700
Storage method	Dummy, 1= if improved storage, 0 otherwise	787	1.18	0.90	0	2
Credit	Dummy, 1= if the household received credit in the previous 12 months, 0 otherwise	788	0.45	0.50	0	1
Oromia	Regional dummy, 1=Oromia, 0 otherwise	790	0.43	0.50	0	1
Amhara	Regional dummy, 1=Amhara, 0 otherwise	790	0.38	0.49	0	1
Labor cost	labor cost incurred in Birr	789	597.10	1560.06	0	20190
lnassets	logarithm of asset value owned by the household	790	6.98	1.31	0.6931472	10.71175
Total input	total input cost in Birr	790	3202.21	4909.38	0	76858
Market info	dummy, 1= if the household accessed market info, 0 otherwise	790	0.27	0.45	0	1
Number of markets	Number of market centers in the area	790	2.82	1.02	1	5
Education	years of education of head	790	2.39	3.25	0	18
Extension	Dummy, 1=if the household accessed	789	0.56	0.50	0	1

	extension, 0 otherwise					
Technology	Dummy, 1=if the household used improved practices, 0 otherwise	789	0.26	0.44	0	1
lnlaborc	logarithm of labor cost	789	3.15	3.29	0	9.912943
lninputc	logarithm of input cost	790	7.31	1.57	0	11.24971
Adult Equivalent	family size in adult equivalent scale	805	4.90	2.12	0.74	15.88
Non-farm income	Dummy, 1=if the household has non-farm income, 0 otherwise	804	0.50	0.50	0	1
Family size	number of household members	805	5.84	2.46	1	18

Table 6: Average Marginal effect after Tobit: conditional on being uncensored

Variable name	dy/dx	Std. Err.	z	P>z	[95% Conf. Interval]	
Technology	-0.487	0.235	-2.08	0.038	-0.947	-0.028
Extension	0.097	0.213	0.45	0.65	-0.321	0.514
Education	-0.068	0.032	-2.15	0.032	-0.130	-0.006
Number of markets	0.155	0.089	1.75	0.081	-0.019	0.329
Market info	-0.091	0.204	-0.45	0.655	-0.490	0.308
Lnassets	0.052	0.091	0.57	0.569	-0.126	0.229
Lninputc	0.370	0.099	3.73	0	0.175	0.565
Lnlaborc	0.058	0.033	1.77	0.077	-0.006	0.122
Oromia_dummy	1.201	0.323	3.72	0	0.568	1.833
Amhara_dummy	1.374	0.326	4.21	0	0.735	2.014
Storage method	0.126	0.111	1.14	0.256	-0.092	0.344
Improved seed	0.000	0.001	0.06	0.956	-0.002	0.002
Land size	0.082	0.090	0.91	0.364	-0.095	0.259
Sex of head	0.223	0.219	1.02	0.307	-0.205	0.651
Credit received	*0.343*	*0.179*	*1.91*	*0.056*	*-0.009*	*0.694*
Adult Equivalent	-0.081	0.048	-1.7	0.089	-0.175	0.012
Non-farm income	-0.053	0.179	-0.29	0.769	-0.404	0.299