The Determinants of Agricultural Productivity and Rural Household Income in Ethiopia

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Abstract

This paper aims at investigating the determinants of agricultural productivity and rural household income in Ethiopia. Three econometric models namely: Pooled ordinary least square (POLS), fixed effects (FE) and random effects (RE) model were used to examine the relationship between productivity and income; using Ethiopian socio-economic survey of 2011/12 and 2013/14 data, collected by CSA of Ethiopia in collaboration with the World Bank.

Results showed that, Land-labor ratio, use of fertilizer, use of pesticide, manure and household size are found to be the most significant variables that affect agricultural labor and land productivity. However, drought has statistically significant and has negative effect on both labor and land productivity by the same magnitude. Labor productivity, non-farm income and land productivity are found to be the most determinants of household income. However, number of dependency ratio is significantly and negatively affects the rural household income. Sex of the household head is the main socio-economic factor for the variation of income among the rural households. The study also concludes that, Labor productivity is the most potent for factor of production and rural household income enhancement. The policy implication of the study is that, increasing land-labor ratio is important for agricultural productivity enhancement and promotion of both farm labor and non-farm income are best focusing to speed up for the enhancement of rural household income.

Key Words: Labor productivity, Land productivity; Rural household income, Rural household panel data, Fixed effect model.

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1. Introduction

Ethiopia is one of the Sub-Saharan African countries which liberalize its economy to maintain in all sectors a sustained economic growth and reduce poverty. Over the last ten years the sustainable economic growth brought with it positive trends in reducing poverty in urban and rural areas: While 38.7% of Ethiopian lived in absolute poverty in 2004/05. However, five years later this was declining to 29.6% in 2010/11. Moreover, poverty head count is still more prevalent in rural 30.4 percent than urban areas 25.7percent in Ethiopia (CSA, 2010/11).

In Ethiopia, about 83.9 % of total population is lives in rural area and agriculture is main source of their livelihood. Since 2010, Agriculture become the second most dominant next to service sector of the country's economy, by providing employment for 80 % of the total labors force and contributes 42.7 % to Gross Domestic Product and 70 percent of foreign exchange earnings (NBE, 2013; CSA, 2013).

Due to its importance, the government of Ethiopia gives high priority to the agriculture sector by setting a strategy of agricultural development led industrialization (ADLI). The main goal of the agricultural policy is not only achieving the sustainable increase in agricultural production and productivity of small holder farmers but also accelerate agricultural commercialization and agro industrial development in the country (PIF, 2010-2020). Agricultural productivity can be increased by using two ways. The first method is through improvement in technology given some level of input and the other option of improving productivity is to enhance the output per household labor ratio of rural household farmers, given fixed level of inputs and technology. This study was mainly concerned about the second option of increasing productivity i.e. output per labor input and output per cultivated area of land.

Land productivity is used by national policy makers to evaluate agricultural production intended to meet national food security needs. But, output per agricultural worker, on the other hand, may be a more important indicator of

rural household standards of living and their welfare (Block, 1995). Therefore, enhancement of agricultural productivity is thus an important condition for alleviating rural poverty, and due to it increases household income and stimulating the growth of non-farm activities among rural households.

However, due to the agriculture sector of Ethiopia is mostly susceptible in seasonal rain fall, the rural households are generating their family income from difference sources to averse the risk associated in agricultural farm sector. As a result the main source of income in most rural household of Ethiopia is derived from farm and non-farm activities. Agriculture is the primary source of rural income as 80% percent of the rural labor force is engaged in this sector (CSA, 2013). Non-farm income of the rural household referred to an income that the rural households generate from none of crop or livestock production during a one year of agriculture production period. Non-agricultural activities are not getting prevalence in rural Ethiopia because households are rarely practicing dominated by a subsistence agriculture sector. As a result of this, the income from nonfarm activity is also very low.

This subsistence agriculture and low level of rural household income is socially and economically could make unstable the rural society. Therefore, it is significantly important to identify the factors that affect agricultural productivity and find the methods of the rural household income improvements.

1.2 Objective of the study

The main objective of this study was to examine the determinants of Agricultural productivity and rural household income in Ethiopia and more specifically the study was:

- To determine the agricultural farm productivity/output per unit of labor input and output per unit of cultivated area of land

- To examine socioeconomic factors which can best predictor for the variation in agricultural productivity and income among rural households
- To examine the most potent productivity to enhance the rural household income
- To recommend possible policy implication based on the research findings.

2. Research Methodology

2.1 Source of data and the type of data used

The data for this research paper is comes from the two round of panel survey of Ethiopian Rural Socioeconomic survey (ERSS), conducted by Central Statistical Agency (CSA) with the collaboration of the World Bank Living Standard Measurement Study (ISLM) team. The survey was conducted in 2011/12 for the first time in Ethiopia in full sample coverage at National level and second round was conducted after two years later in 2013/14.

2.2 Methods of data analysis

Quantitative methods were used to analysis the data. Mean tabulation and frequency distribution was used to analyze in detail. On top of that F-test and Chi-square statistics is implemented to measure the mean and percentage difference between productivity and income of the rural households. The log-linear of Cobb_Dauglas production function of the within-group or LSDV, the random effect (RE) and the fixed effect (FE) model was used for the determinants of agricultural productivity and the IVreg2 (2SLS), the random effect (RE) as well as the fixed effect (FE) model was employed for the estimation of the determinants of rural household income.

2.3 Empirical productivity model specification

The current Cobb-Douglas production function analysis consider all the factors of production such as cultivated area of land, chemical fertilizer, number of oxen as proxy for capital input, etc are considered.

$$y_{it} = \alpha(L_{it}^{\beta_1} K_{it}^{\beta_2}) e^{\mu_{it}} \quad \textbf{(1)}$$

Where: Y_{it} = is the value of the i^{th} household's all farm output in Ethiopian birr during Period t

L_{it} = is the i^{th} labor inputs used during period t
K_{it} = is the i^{th} capital inputs at a time t
μ_{it} = the disturbance or an error term
β_1 and β_2 = output elasticity of labor and capital

If we transform equation (1) in its log-transformation form, it will give us:

$$\ln Y_{it} = \beta_i + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \mu_{it} \quad \textbf{(2)}$$

Therefore, in the case of our several dependant variables the ln-linear model would be:

$$\ln Y_{it} = \beta_{0i} + \beta_1 \ln Al_{it} + \beta_2 \ln A_{it} + \beta_3 \ln RAV_{it} + \beta_4 \ln FET_{it} + \beta_5 \ln OX_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \beta_8 HHS_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \quad \textbf{(3)}$$

Where,
$\ln Y_{it}$ = the log of total farm output produced by i^{th} household during period t
$\ln Al_{it}$ = the log of i^{th} household agricultural labor inputs during period t
$\ln A_{it}$ = the log of cultivated land area of the i^{th} household during period t
$\ln RAV_{it}$ = the log of real asset value of the i^{th} household during period t
FET_{it} = the amount of chemical fertilizer used by i^{th} household during period t
OX_{it} = the number of oxen used for plough by i^{th} household during period t
AG_{it} = The Age of the household head during period t
EDU_{it} = Educational level of the i^{th} household head during the period t
HHS_{it} = family size of the i^{th} household during period t
SEX_{it} = Sex of the i^{th} household head during period t
PES_{it} = if the i^{th} household were used pesticide or not during period t
DRT_{it} = if drought was happened to the i^{th} household farms during the pried t

CRD_{it} = if the i^{th} household was got credit during period t
$EXTN_{it}$ = if the household used extension service during the period t
$IRRN_{it}$ = if the household used irrigation during the period t
$MANURE_{it}$ = if the household used animal manure during the period t

But our interest is to come up with the labor and Land productivity equation and hence, let us first divide both sides of equation (3) by agricultural farm labor force (AL), to determine the labor productivity equation. According to Ramirez (2006), we will have aggregated output per unit of labor as a measure of labor productivity and taking log of both sides of the equation it will gives us;

$$\ln\left(\frac{Y}{AL}\right)_{it} = \beta_{0i} + \beta_1 \ln\left(\frac{AL}{AL}\right)_{it} + \beta_2 \ln\left(\frac{A}{AL}\right)_{it} + \beta_3 \ln\left(\frac{RAI}{AL}\right)_{it} + \beta_4\left(\frac{FET}{AL}\right)_{it} + \beta_5\left(\frac{OX}{AL}\right)_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \beta_8 HHS_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \quad \textbf{(4)}$$

Where $\ln\left(\frac{Y}{AL}\right)$ = is a measure of partial labor productivity. It is worth to mention that our productivity measurement is partial.
If we put equation (4) in a compact or reduced form in the following method:

$$\ln\left(\frac{Y}{AL}\right)_{it} = \beta_{0i} + \beta_i \sum_{j=1}^{n} X_{it} + \gamma_i \sum_{k=1}^{n} D_{it} + e_{it} \quad \textbf{(5)}$$

Where, j = 1, 2, ..., 8 and
K = 1, 2, ..., 7

Similarly we compute the Land productivity equation based on equation (3) above by dividing the right and the left hand sides by cultivated area of land (A). Then, we will have aggregated output per cultivated area of land as a measure of land productivity will gives us;

$$\ln\left(\frac{Y}{A}\right)_{it} = \beta_{0i} + \beta_1 \ln\left(\frac{AL}{A}\right)_{it} + \beta_2 \ln\left(\frac{A}{A}\right)_{it} + \beta_3 \ln\left(\frac{RAI}{A}\right)_{it} + \beta_4\left(\frac{FET}{A}\right)_{it} + \beta_5\left(\frac{OX}{A}\right)_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \quad \textbf{(6)}$$

Therefore, the reduced form of equation (6) will gives us the following equation (7):

$$\ln\left(\frac{Y}{A}\right)_{it} = \beta_{0i} + \beta_i \sum_{j=1}^{n} X_{it} + \gamma_i \sum_{k=1}^{n} D_{it} + e_{it} \quad \textbf{(7)}$$

Where, $\ln\left(\frac{Y}{A}\right)$= is a measure of partial land productivity and, j =1, 2, ... 3

i= 1, 2, ... 7

During the pooled OLS model is employed a random variable ε_{it} are assumed to be iidN(0, δ_{ε}^2).

2.4 Estimation technique

We use equation (8) and (9) to estimate the labor and land partial factor productivity measurement specified under equation (5) and (7) respectively. For the model estimation, we were employ panel data estimation technique. Following Baltagi (2001), Gujarati and Porter (2009), and Greene (2003) panel data regression model presented below.

$$Y_{it} = \alpha_{it} + \beta X_{it} + U_{it}, \quad i = 1....., N \ \& \ t = 1, ... , T. \quad \textbf{(8)}$$

Where,

Y_{it} = is the dependant variable

X_{it} = is the independent variable

α_{it} = is the unobserved individual heterogeneity or the individual fixed effect

β = is the parameter to be estimated

U_{it} = is the residual

In order to test the pooled OLS model is fitted or not, we will be employee the standard F-test by using equation 11. The F-test will be used to check fixed effect against Pooled OLS Method (Common constant). The null hypothesis (equation 10) is that all the intercepts are the same and the Pooled OLS Method is applicable.

$$H_0: \alpha_1 = \alpha_2 = ... = \alpha_N \quad \textbf{(10)}$$

$$F = \frac{(R^2_{UR} - R^2_R)/J}{(1-R^2_{UR})/(n-k)} \quad (11)$$

Where, R^2_{UR} = Unrestricted R squared

R^2_R = Restricted R squared

J = Number of restrictions

n = Total number of observations

k = number of parameters in the unrestricted regression

We also use the Houseman test to select the best efficient model among the random effect and the fixed effect model in order to meet our objective.

2.5 Empirical model specification for rural household income

By following Simler *et al.* (2004) and Demeke *et al.* (2003), we try to estimate the determinants of the rural household per capita income. The framework is the unobserved effects model which is adapted from Wooldridge (2009) and Greene (2003).

$$\ln(I_{it}) = \beta_i + \gamma prod_{it} + \beta X_{it} + \varepsilon_{it}, \quad i = 1, ---, N, \; t = 1, .., T \quad (12)$$

Where, $\ln(I_{it})$ = is the natural logarithm of the rural household income per capita of the i-th household

β_i = is an individual-specific or unobserved effects which is fixed over time.

βX_{it} = are vectors of explanatory variables which serve as control.

$\gamma prod_{it}$ = represents the agricultural productivity of farm households.

ε_{it} = the error terms which are assumed to be uncorrelated with the exogenous Variables X_{it} with mean zero and variance δ^2_ε

There are also dummy variables in our regression model. According to Verbeek, (2004) equation (11) will be specified with dummy variable as follows:

$$I_{it} = \sum_{j=1}^{N} \alpha_j d_{ij} + \gamma prod_{it} + x'_{it}\beta + \varepsilon_{it} \quad \textbf{(13)}$$

Where, d_{ij} = is a dummy variables which takes 1or 0 for j = (1, ---, N)

However, the agricultural labor productivity and land productivity were characterized by endogenity problems. Therefore, to overcome these endogenity problems, we use z_{it} as instrumental variables (IV's) for the productivity variables.

The productivity of X_{it} was instrumented by:

$$prod_{it} = \pi_1 z_{it} + \pi_2 x_{it} + v_{it} \quad \textbf{(14)}$$

Where, The agricultural productivity and instrumental variables (IV's) z_{it} are correlated, i.e **Cov** $(z_{it}, prod_{it}) \neq 0$ but the idiosyncratic error term is uncorrelated with the instrumental variables (IV's), thus **cov** $(z_{it}, \varepsilon_{it}) = 0$

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2.5.1 Estimation technique

The estimation technique of the determinants of the rural household income were used the IVreg2 or two stages least square (2SLS), fixed effect (FE) and the random effect (RE) estimator based on equation (13) and (14) above.

This equation also enables us to investigate the change in income per-capita per-household by applying the fixed effect estimation.

3. Econometric Results and Discussion

3.1 Econometric results of the agricultural labor productivity

There were different demographic and socio-economic factors that were contributing in the determinants of agricultural labor productivity of the rural farm household's in Ethiopia. In order to identify the significant factors, we employ the pooled OLS, the within-group, the fixed effect and the random effect models are applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

F-test for labor productivity

Test for differing group intercepts:-
Null hypothesis: The groups have a common intercept
Test statistic: F (14, 2124) = 110.84
With p-value = P (F (14, 2124) > 110.84) = 3.38

On the basis of the F-statistics test, we decided to use the fixed effect model, and therefore, only the fixed effect model results will be presented and discussed. The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem was adjusted by regressing all model used for estimation with robust standard, and the multicollinearity problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. As a result we don't find any multicollinearity problem during the estimation for the determinants of labor productivity.

To determine the agricultural labor productivity in rural households of Ethiopia, the fixes effect model was applied. The parameters of the fixed effect estimation model of the partial factor labor Productivity of farm household indicates that, most variables were statistically significant. However, real asset value per unit of labor, number of oxen per unit of labor, educational level of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of labor productivity.

One known reason for educational level of the household heads do not significant is that, out of 2,236 household head there were only about 700 household heads were educated in the survey data set and off these 700 households only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period.

The result of the fixed effect estimation model shows that, cultivated area of land per unit of labor, the use of chemical fertilizer inputs, the use of pesticide, use of extension program, the use of manure, the number of household size and age of the household head are found to be the determinants of the agricultural labor productivity. However, the drought variable was significantly and negatively affects the agricultural labor productivity of the sampled rural households. More specifically, cultivated area of land per unit of farm labor input was a significant contribution for the positive change of labor productivity during period of analysis; as the cultivated area of land per unit of agricultural labor increases by one percent, the labor productivity increases by 0.83 percent. This finding is consistence with the finding of Joseph Owuor's in Kenya. He was concluded that, labor productivity and land productivity are consistent, positively correlated and significant. The result implies that, the availability of agricultural cultivated land increases labor productivity in the sampled area of rural households. Therefore, it could be good if the government facilitate the access of land to landless, especially for the youngsters those who are within the household.

The fixed effect result shows that, there is a significant labor productivity difference between chemical fertilize user household and non user. As the household are increases the use of chemical fertilizer inputs by one unit the labor productivity increases by about 0.25 units and vis-versal for non user households. The use of pesticide input in farm production processes was also statistically significant at 1 percent level of significant, which means, as the household increases the use of pesticide by one unit, the labor productivity also increases by about 0.12 units. Therefore, accessing and advising the rural household to the use of pesticide inputs during their farm production processes would enhance labor productivity in rural households.

One of the important finding of this study was that, when the drought occurs in one agricultural season in Ethiopia, the labor productivity of the rural household declines by about 0.25 units and it is statistically significant at 1 percent level. This implies that the rain dependant agriculture is risky for the farm household labor productivity enhancement. Therefore, promotion of the use of irrigation system or any other source of water is useful during the drought season so as to increase the labor productivity of rural farm households.

Surprisingly, as the number of household member increases by one unit the labor productivity of the household increases by 0.21 units and it is also significant at one percent level of significant. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production processes. As a result having more labor with in a household would be able to a high possibility of farm management work to increase farm output.

Table 1: The labor productivity of with-group, fixed-effect & random-effect estimates

Explanatory Variables	Coefficients		
	Within-group	**Fixed-effect**	**Random-effect**
Log of Land in hectare per unit of labor	0.826*	0.831*	0.721*
	(0.023)	(0.032)	(0.023)
Log of Real Asset Value (in birr) per unit of labor	0.019	0.013	0.037**
	(0.018)	(0.025)	(0.017)
Chemical fertilizer (in Kg) per unit of labor	-0.123*	-0.249*	-0.334*
	(0.021)	(0.052)	(0.040)
Number of ploughed oxen per unit of labor	0.061	0.097	-0.255***
	(0.161)	(0.233)	(0.145)
Age of household head	0.025*	0.024*	0.002
	(0.003)	(0.005)	(0.002)
Educational status of household head	0.013	0.017	0.165*
	(0.037)	(0.053)	(0.035)
Household size	0.220*	0.205*	0.018
	(0.014)	(0.020)	(0.058)
Sex of household head (male =1)	-0.012	-0.135	0.042*
	(0.0245)	(0.129)	(0.010)
Pesticide (use =1)	0.046**	0.119*	0.161*
	(0.021)	(0.044)	(0.037)
Drought (yes =1)	-0.098*	-0.247*	-0.240*
	(0.036)	(0.071)	(0.061)
Credit access (yes =1)	0.016	0.063	-0.013
	(0.019)	(0.047)	(0.037)
Extension service (yes =1)	0.033***	0.142*	-0.004
	(0.018)	(0.048)	(0.035)
Irrigation (use =1)	0.0178104	0.057	0.185*
	(0.025)	(0.075)	(0.055)
Manure (use =1)	0.032***	0.074**	0.193*
	(0.018)	(0.045)	(0.036)
Constant	-0.015*	7.252*	8.459*
	(0.026)	(0.294)	(0.158)5
Number of Observations	4353	4353	4353
Prob>F	0.0000	0.0000	0.000
R-squared	0.4128	0.4222	0.3872
corr(a i , X b)		-0.3916	0
			(assumed)
sigma_u		1.266	0.879
sigma_e		0.815	0.815
Rho		0.707	0.538

Source: Computed from Ethiopian socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of labor productivity measured in output per man-day; *, ** and *** represents the coefficients are significant at 1, 5 and 10 percent level respectively.

Another variable, the use of extension service and manure was also statistically significant at 1 and 10 percent significant level respectively. The use of extension service increases the farm household labor productivity significantly by 0.14 units as the households were got the service during one production seasons of the survey period. It is also consistence with the finding of Asres Elias *et.al* (2013) in Ethiopia, during their study of the Effect of agricultural extension program on small holder's farm productivity. There for, by expanding and encouraging the farm household participation rate for the use of extension program is still important for the labor productivity enhancement since the extension user households are more productive than non users.

Using manure is also important variables for the rural household labor productivity enhancement, which shows that, the labor productivity increases by 0.07 units as the farm household's uses manure for their farm production process in one production period. This implies that, animal dung is very important as the chemical fertilizer may not affordable for some poor rural farm households. The finding is also consistent with Wassie (2012) in Ethiopia indicated that, manure maintains soil fertility.

There was also age of the household head is statistically significant at 1 percent level. This implies that as the age of the household head increases by one more year the labor productivity of the rural household also shows slight increments by 0.02 units. One reason would be the mean of the household head age was around 45 years and more than 47 percent of the household head age was less than 40 years old as a result the possibility of young household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm labor productivity.

Hausman-test:

Test: Ho: difference in coefficients not systematic

chi2 (14) = 251.46

Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. Due to the fact that, the analysis of this study is made on the bases of the result of the within-group and the fixed effect model, due to the random effect model was rejected in favor of fixed effect model by Hausman test.

3.2 Econometric results of the agricultural land productivity

Here also there are different demographic and socio-economic factors that were contributing in the determinants of agricultural land productivity of the rural farm household's in Ethiopia. In order to identify the significant factors, we employ the pooled OLS, the within-group, the fixed effect and the random effect models were applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

F-test for land productivity
Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F (14, 2124) = 20.26
With p-value = P (F (14, 2124) > 20.26) = 3.41

On the basis of the F-statistics test, we decided to use the fixed effect model. And hence, only the fixed effect model result will be presented and discussed. The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem was adjusted by regresses of the entire model used for estimation, with robust standard and the multicollinearity problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. As a result we don't find any multicollinearity problem during the estimation for the determinants of land productivity.

To determine the agricultural land productivity in rural households of Ethiopia, the fixes effect model was applied. The parameters of the fixed effect estimation model of the partial factor land productivity of the Ethiopian rural farm household indicate that, most of the variables were statistically significant during the survey period of 2012-2014 (Table 2 above). However, real asset value per unit of land, educational status of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of land productivity.

One known reason for educational level of the household heads do not significant is that, out of 2,236 household heads, there were only about 700 household heads were educated in the survey data set and off these 700 households, only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period.

Despite the fact that, the finding of the fixed effect estimation model shows that, agricultural labor per unit of cultivated area of land, the use of pesticides and extension service, the number of household member size, the number of oxen used for ploughed and the age of the household head were found to be the determinants of agricultural land productivity of rural households.

However, the cause of drought during the production season was significantly and negatively affects the rural households land productivity. The land productivity shows a slight change when it compares to labor productivity changes during the same period of analysis. It indicates that, as the agricultural labor per unit of cultivated area of land was increases by one percent, land productivity increases by 0.14 percent. This output was almost the same with the within-group estimation output. The result implies that, the increase of labor-land ratio increases land productivity of rural households. Therefore, it could be good if the government facilitate the access of land to landless, especially for the youngsters those who are within the household. The finding is also consistence with Joseph Owuor in Kenya.

The result of this study in both, the within-group estimation and fixed effect model, exactly answers the question of the most potent of agricultural productivity so as labor productivity is the most potent for agricultural productivity than land productivity in the rural households.

The use of pesticide input in farm production processes was also statistically significant at one percent level of significant, which means, as the household increases the use of pesticide by one unit, land productivity increases by 0.12 units. Therefore, accessing and advising the rural household to use the pesticide inputs during their farm production processes would enhance the land productivity of rural households.

One of the important finding of this study is that, when the drought occurs in one agricultural season in Ethiopia, the land productivity of the rural household declines by 0.25 units and statistically significant at l percent level. This implies that the rain dependant agriculture is risky for the farm household land productivity enhancement. Therefore, promotion of the use of irrigation system or any other source of water is useful during the drought season so as to increase the land productivity of rural farm households.

Surprisingly, as the number of household member increases by one unit, land productivity increases by 0.21 units and it is also significant at one percent level of significant. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production processes. As a result having more labor with in a household would be able to a high possibility of farm management work like timely land preparation to increase farm output.

Using manure is also important variables for the rural household's land productivity enhancement, which shows that, the land productivity increases by 0.09 units as the farm household's uses manure for their farm production process in one production period. This implies that, animal dung is very important as the chemical fertilizer may not affordable for some poor rural farm households. The finding is also consistent with Wassie (2012) in Ethiopia indicated that, manure maintains soil fertility.

The use of extension service increases the farm household land productivity by 0.14 units as the households were got the extension service during one production seasons of the survey period. There for, by expanding and encouraging the farm household participation rate for the use of extension program is still important for the land productivity enhancement since the extension user households are more productive than non user. This result is consistent with Asres Elias *et. al* (2013) in Ethiopia.

The number of ploughed oxen variable is statistically significant at 1 percent level shows that, a little positive change in land productivity as the household use the one extra more ploughed ox, land productivity changes by 0.00073 units. This implies that land productivity is not associated more cultivating area of land but use of farm practicing is important for land productivity enhancement in rural farm households of Ethiopia.

There was also age of the household head is statistically significant at one percent level. It implies that as the age of the household was increases by one more year the land productivity of the rural household shows a slight increment by 0.02 units. One reason would be the mean of the household head age was 45 years, as a result the possibility of yang household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm land productivity.

Table 2: The land Productivity of with-group, fixed-effect & random-effect estimates

Explanatory Variables	Coefficients		
	Within-group	Fixed effect	Random effect
Log of labor per unit of land in hectare	0.149*	0.144*	0.253*
	(0.023)	(0.032)	(0.023)
Log of Real Asset Value per unit land in hectare	0.014	0.013	0.032**
	(0.017)	(0.024)	(0.017)
Chemical fertilizer per unit of land in hectare	-0.125*	-0.250*	-0.335*
	(0.021)	(0.052)	(0.040)
Number of ploughed oxen per unit of land	0.0007*	0.0007*	0.0003*
	(0.0001)	(0.0001)	(0.0001)
Age of household head	0.025*	0.024*	0.002
	(0.003)	(0.005)	(0.002)
Educational status of household head	0.0003	0.018	0.167*
	(0.038)	(0.053)	(0.035)
Household size	0.223*	0.205*	0.043*
	(0.014)	(0.020)	(0.010)
Sex of household head (male =1)	-0.009	-0.179	0.012
	(0.026)	(0.125)	(0.058)
Pesticide (use =1)	0.046**	0.120*	0.162*
	(0.021)	(0.044)	(0.037)
Drought (yes =1)	-0.097*	-0.248*	-0.244*
	(0.036)	(0.071)	(0.061)
Credit access (yes =1)	0.015	0.058	-0.010
	(0.019)	(0.047)	(0.037)
Extension service (yes =1)	0.035**	0.142*	-0.002
	(0.018)	(0.048)	(0.035)
Irrigation (use =1)	0.019	0.056	0.188*
	(0.025)	(0.075)	(0.055)
Manure (use =1)	0.035** *	0.088**	0.194*
	(0.018)	(0.045)	(0.036)
Constant	-0.023*	7.340*	8.445*
	(0.027)	(0.289)	(0.159)
Number of Observations	4353	4353	4353
Prob>F	0.0000	0.000	0.000
R-squared	0.1070	0.118	0.062
corr(a i , X b)		-0.401	0 (assumed)
sigma_u		1.265	0.885
sigma_e		0.814	0.814
Rho		0.707	0.541

Source: Computed from Ethiopian Socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of land productivity measured in output per land-hectare; * and ** represents the coefficients are significant at 1 and 5 percent level respectively.

Hausman-test:

Test: Ho: difference in coefficients not systematic
chi2 (14) = 248.21
Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. As a result, the analysis of this study was made bases on the result of the fixed effect model.

3.3 Econometric Results of Rural household Income

There were different demographic and socio-economic factors that were contributing in the determinants of rural household income. In order to identify the significant factors, we employ the pooled OLS, the 2SLS, the fixed effect and the random effect models were applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem is adjusted by regresses all model used for estimation, with robust standard and the multicollinearity problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. We were found an endogenity problem during the estimation of rural household income per-capita among the variables of productivity. To obtain unbiased and consistent estimators, we applied IVreg2 Two Stage Least Squares (2SLS) approach with it's the two conditions of a valid instruments i.e. instrument relevance: $corr(z_i, x_i)\neq 0$ and instrument exogeniety: $corr(z_i, v_i)=0$ were fulfilled.

In the 2SLS (IVreg2) regression, due to the two explanatory variables of agricultural productivity was causing an endogenity problem, we used two instrumental variables (a dummy variable if crop was affected due to some

household members were got chronic disease (CDS) and a dummy variable if crops were damaged to instrument both the agricultural labor & land productivity. The identification criteria for all instruments are also fulfilled. After controlling for the endogenity problem for the productivity variables, in the fixed effect regression result; most of the parameters used to determine the rural household income shows statistically significant during the period of 2012-2014. However, age of the household head, educational status of the household head, number of household size and credit access were not found to significant for the determinants of rural household income in sampled area of Ethiopia.

The IV-fixed effect regression output indicates that, labor productivity, farm land productivity, owing number of livestock (in tropical livestock unit), non-farm income, sex of the household head and number of dependant in the household are found to be significant determinants of the rural household income. But, the number of the household members those who are dependant was found to significantly and negatively affects the household income in rural households. This study output is consistence with the finding of Vincent Leyaro and Oliver Morrissey in Tanzania during their study of the "Protection and the determinants of household income in Tanzania 1991 – 2007."

The agricultural labor productivity which is the farm output per unit of labor input is statistically significant at 1 percent level. The result of the fixed effect model shows that, increasing the labor productivity by one percent, the rural household income increases by 0.86 percent. The output of the fixed effect model shows that, the labor productivity is the most potent than the land productivity variable used in the regression for the household income in the rural Ethiopia. Therefore, the government and other stake holder should give more attention for farther improvements of labor productivity to enhance rural household income.

Table 3: Rural Household Income OLS, IVreg2, Fixed-effect & IV_fixed effect estimates

Explanatory Variables	Coefficients			
	Pooled OLS	IV-reg	Fixed	IV-Fixed
Log of Labor productivity	0.588*	5.295**	0.598*	0.856*
	(0.017)	(2.573)	(0.015)	(0.213)
Log of Land productivity	0.346*	3.317***	0.262*	0.146**
	(0.019)	(2.008)	(0.019)	(0.179)
Total Livestock Units	0.066*	0.199	0.023*	0.022*
	(0.006)	(0.147)	(0.007)	(0.007)
Number of dependant	-0.588*	-1.928*	-0.221*	-0.229*
	(0.064)	(0.825)	(0.092)	(0.098)
Age of the household head	0.004*	0.016***	0.002	0.002
	(0.0009)	(0.008)	(0.003)	(0.003)
Educational status of household head	0.026	0.160	0.031	0.033
	(0.023)	(0.149)	(0.039)	(0.042)
Household size	0.083*	0.222*	0.006*	0.004
	(0.007)	(0.088)	(0.015)	(0.016)
Sex of household head (male =1)	0.317*	0.913	0.231**	0.156*
	(0.039)	(0.709)	(0.102)	(0.125)
Non-farm income	0.202*	0.975**	0.279*	0.283*
	(0.030)	(0.467)	(0.029)	(0.032)
Credit access (yes =1)	0.234*	0.796*	0.041	0.048
	(0.027)	(0.339)	(0.030)	(0.033)
Constant	1.097*	4.481*	2.719*	3.083*
	(0.157)	(2.067)	(.204)	(0.370)
Number of Observations	4309	4309	4309	4309
Prob>F	0.0000	0.0000	0.0000	0.0000
R-square	0.681			
corr(a i , X b)			0.119	-0.033
sigma_u			0.842	0.871
sigma_e			0.535	0.570
Rho			0.712	0.700
Centered R-square		0.898		
Uncentered R-square		0.7714		
Under identification test (Kleibergen-Paap rk LM statistic):		3.333		
P-value of under identification LM statistics		0.018		
Hansen J statistics		0.153		
P-value of Hansen J statistics		0.6953		

Source: Computed from Ethiopian Socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of Income in birr value; *, * and *** represents the coefficients are significant at 1, 5 and 10 percent level respectively.

The agricultural land productivity which is the farm output per unit of cultivated area of farm input was statistically significant at 10 percent level. The result of the fixed effect model shows that, increasing the land productivity by one percent, the rural household income also increases by 0.15 percent. The finding of the fixed effect model shows that, the land productivity is the third contributor for the enhancement of per-capita income next to labor productivity and non farm income in the sampled rural households. Therefore, the government will give more attention to increase the land productivity in rural farm household to farther per capital income.

Productivity enhancements

Another variable used for the determinants of rural household income was the number of dependency ratio per households also significant at 1 level stated that, it is negatively affects the household income. More specifically, if the number of dependency ratio increases by one unit, income of rural household declines by 0.23 units. This tells us limiting the number of dependant family member in the household is important to increase the wealth status of the rural household.

The household generated their income from nonfarm activity for their livelihood is also statistically significant at one percent level, which means, as the household got one additional units of nonfarm income the entire household income was significantly increases by 0.28 units. However, the income from the nonfarm was very few when it compares with the agricultural farm labor productivity. Fully concentrating only on farm activity will limit the rural household income and wealth development. The fixed effect result shows that, the labor of the rural household was fully engaged with drought affected farm activity in rural Ethiopia. Therefore, the government should have to be harmonizing the wide gap between farm and non farm income to increase the nonfarm income generating activity, since the farm production is usually associated by drought risk. Extension worker and other stockholder should advise the rural farm household to generate the nonfarm income parallel to their farm production process.

Another variable, the sex of the household head also significant at 1 percent level shows that, there is a difference in income among male headed and female headed household. The result indicated that per-capital income was higher for male-headed households than female headed household by 0.16 units. This implies that empowering of women will be crucial for the household wealth improving in rural Ethiopia.

Owning of livestock at tropical livestock unit also statistically significant at 1 level shows that, as the number of livestock owing (in tropical livestock unit) increases by one unit the income of the rural household raises by 0.02 units.

Hausman-test

Test: Ho: difference in coefficients not systematic
chi2 (9) = 2.91
Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. As a result of this, the analysis of this study is made on the bases of the result of the fixed effect model.

4 Summary and Conclusions

Using the panel data of Ethiopian Rural Socio-economic Survey (ERSS), this study investigated the determinants of agricultural labor productivity and rural household income in Ethiopia during the period of 2012 - 2014. Three panel data analysis methods are used: the pooled ordinary least square method (POLS), fixed effects (FE) method and random effects (RE) method. Based on Hausman test, fixed effect (FE) method was found the most appropriate model.

The determinants of agricultural productivity in rural households do not much vary across labor productivity and land productivity. Cultivated area of land per unit of labor ratio, the number of household member size, the use of fertilizer, the use of extension service, the use of pesticide, the use of manure

and age of the household head are the main determinants of the agricultural labor productivity. The fixed effect results show that, land-labor ratio, use of fertilizer, use of pesticide and extension service variables are the most significant variables through which we may improve farm labor productivity of rural households. This could imply that, households' labor productivity gain could be attained if we focus on improving the land-labor ratio, use of fertilizer, use of pesticide and extension service. However, land-labor ratio is more challenging than improving the use of fertilizer, pesticide and extension service with increased rural yang agricultural labor force population pressure. But it is possible by mobilizing the farm labor force to the other potential cultivable area of land.

Similarly, labor-land ratio, use of fertilizer, the number of household member size, the use of extension service, the use of pesticide, the use of manure, the number of oxen used and age of the household head are the main determinants of agricultural land productivity. The fixed effect results show that, labor-land ratio, the use of fertilizer, the number of household member size, the use of manure, use of pesticide and extension service variables are the most significant variables through which we may improve farm land productivity of rural households. This also could imply that, households' land productivity gain could be attained if we focus on improving the labor-land ratio, the use of fertilizer, pesticide inputs and extension service. However, improving labor-land ratio is more challenging than improving the use of pesticide and extension service with increased rural yang population pressure. But it is possible by mobilizing farm labor force to the other potential cultivable area of land.

Off all the variables used in the regression of agricultural productivity, cultivated area of land perunit of labor is the most significant effect on the determinants of labor productivity and fertilizer inputs and the number of household size is found to the most significant effect on the determinants of land productivity in the rural household's of Ethiopia. Therefore this study concludes that, the agricultural labor productivity is the most potent factor of production than land productivity for the change of agricultural productivity in rural households. However, drought variable included in the regression

also significantly and negatively affects both labor and land productivity of rural farm households in Ethiopia.

The fixed effect result shows that, both labor and land productivity, household's non farm income, the livestock owning in tropical livestock units and sex of the household head are the main determinates of rural household income in Ethiopia. However, the number of dependant household member significantly and negatively affects rural household income. The result also shows that, labor productivity has the major effect among the variable used in the regression for the change of rural household per capita income enhancement. The finding of the fixed effect regression model supports the view that improvements in agricultural productivity can have substantial positive impacts on household income per capita. Especially improvements in labor productivity of household through better resource allocation and use of necessary inputs can increase the per capita income of the rural households.

There were also a socioeconomic factors that explain the variation in income among the rural households.

4.1 Policy implications

This study has tried to identify the determinants of agricultural productivity and rural household incomes in Ethiopia. Based on the results obtained from the study, we suggest some policy intervention areas should be required. The policy implications that can be derived from this empirical study are:

- To increase the agricultural productivity of farm household's, by reducing the drought risk through rural environmental protection, increase land-labor ratio. The possible ways of application could be through different methods like arranging financial sources that can used for the purchase of different variable inputs and developing a work frame for non farm income employment opportunities in the rural labor market as well as shift the excessive farm labor force to the other potential cultivable area.

- To increase the rural household income, needs improvements in land-labor ratio of farmers through better allocation of financial resource.
- The combined effort is needed to design policy interventions for not only increasing labor productivity but also reducing number of dependency ratio of the household and drought risk which adversely affects labor productivity growth.
- Both agricultural labor and land productivity are important for rural household income enhancement but agricultural labor and land productivity alone does not increased rural household per capita income. Increasing the non farm income was also important for the increasing of rural household per capita income.
- Promotion of both farm labor productivity and non farm income are best focusing to speed up the enhancement of rural household per capita income.
- It is better to strengthening the capacity of the local and federal administrative level, about the environmental protection system and rehabilitation program to protect the variations of climate over time, especially in areas adversely affected by a drought factor.

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