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***A*bstract:** Agriculture is the backbone of the Ethiopian economy which accounts for more than 40 % of the GDP and 90 % of employment source for the rural population. With an objective of analyzing the determinants of the partial factor productivity of the small landholder farmers in Northern Ethiopia, a two-year panel data developed by the Central Statistical Authority and the World Bank Welfare Group, was used. The econometrics models for random and fixed effect were employed. Firstly, land productivity in Northern Ethiopia is determined by access to credit, amount of fertilizer used, households' oxen holding, farm asset of the household, the age of the head of the household and access to agricultural extension services. Secondly, labor productivity is influenced by land per labor, fertilizer per labor, credit accesses, oxen per labor and age of the household head at the smaller holder farmers. Based on these determinants, we suggest the following policy options to boost the land and labor productivity in Northern Ethiopia: (i) improving access for extension services, (ii) expanding irrigation practices, (iii) enhancing awareness of households in the utilization of pesticides, improved seeds, and credit services and (iv) strengthening and establishing farm associations, local institutional arrangements and (v) introducing and strengthening experiences sharing scheme.

Keywords: Partial factor productivity, Determinants, Fixed effect, Random effect, Ethiopia.

JEL Classifications: N50, O13, Q15, Q19

1. Introduction

In general, Ethiopia is referred to as an agricultural country: about 83.9% of total population is living in the rural area depending on agriculture as the main source of their livelihood. Since 2010, agriculture becomes the second dominant sector next to service sector of the Ethiopia's economy, which provides employment for 80% of the total labors force and contributes 42.7% to gross domestic product and 70% of export (CSA, 2013).

The current promising and continuous economic growth in Ethiopia is mainly the result of the different policies and strategies the nation implemented immediately since the fall of the command government. The Ethiopia government has implemented different poverty-reducing policies and strategies to reduce the intensity of poverty and hunger in Ethiopia. In the beginning, the government has developed the Agricultural Development Led Industrialization (ADLI) strategy in 1994, focusing to achieving industrialization through boosting agricultural growth and establishing a strong tie between the agricultural and the industrial sectors. Following this strategy, several different strategies were designed and implemented with the intention of addressing the extreme poverty and food insecurity in Ethiopia. Concretizing the ideas of the ADLI and attaining the Millennium Development Goals (MDGs), or Sustainable Development and Poverty Reduction Program (SDPRP) for 2002/03~2004/05, was a strategy designed to address poverty and attract the interest of the world community, donors, and special interest groups.

In this strategy, significant recognition has been still given to the agricultural sector and skill development for farmers training, water harvesting practices, marketing and cooperative and microfinance institution serving to rural households were getting due attention. Observing the difficulties and implementation problems in SDPRP and giving higher recognition to small farmer households, the Ethiopia government has implemented a Plan for Accelerated and Sustained Development to End Poverty (PASDEP) for 2005/06~2009/10. These related development agendas and strategies have brought a significant effect on the Ethiopian economy. To sustain this economic growth and to renovate it in short period to the highest level, Ethiopia has designed and implemented a Growth and Transformation Plan (GTP) for five years since 2010. It is has a goal of accomplishing the Millennium Development Goals and put a long-term dream to achieve economic successes. The main development goal of the GTP is not only to bring and ensure sustainable economic growth and fair distribution, and thus increase the path of economic progress achieved for the last years, but also to end the level of poverty and food insecurity in Ethiopia. Now, Ethiopia is in the second year of its second cycle of the Growth and Transformation Plan.

Ethiopia has achieved a continuous and remarkable economic growth rate: averaging GDP growth of 10.8 percent for more than ten consecutive years since 2005. It has been recognized by different international organizations and governments as the remarkable achievement of the nation. Reports from the International Monetary Fund (IMF) revealed that Ethiopia is among the five fastest-growing countries in the world. In 2013/14, Ethiopia economy has grown by 10.3% for its eleventh year of success (UNDP, 2015).

Agriculture is a means of life, a source of income and employment and a survival kit for a majority of Ethiopians since around 84 percent of the people are living in rural areas. Successful progression in the agricultural sector and its changes in productivity directly improve the well-being of most of the rural poor and also increase the GDP of the nation (Zewdu *et al.*, 2012). As a strategic tool to

accelerate the transformation of the Ethiopian economy, the government has increased and widened its public investment in agriculture for fostering the growth of the sector (MoFED, 2012). Nevertheless, this spending did not bring the expected result due to the fact that the high growth of the population in Ethiopia has caused the investments to delay those carried out in the rural areas.

Moreover, there are not significant empirical works and documentation with respect to the contributions of these rural targeted public expenditures in terms of their contribution to enhancing agricultural productivity, poverty reduction, and the channels through which they affect the livelihood of the rural community at the household level.

To change the agricultural productivity and improve the livelihood of the rural households, the Ethiopia government has introduced different supporting policies and programs. As result, there is an increase in the total agricultural production in Ethiopia. Allocating and educating extension workers, introducing different agricultural packages, credits and programs, and providing selected agricultural inputs are some of the resources that are made available to farmers to enhance their productivity and livelihood (CSA**,** 2013)**.** Despite all these efforts of the government, the agricultural productivity and farm household livelihood are still very miserable in Ethiopia. As a result, every year more than 10 million people depend on food aid to sustain their life. In the year 2015, however, because of the climate change and poor productivity of agriculture in Ethiopia, more than 15 million people have faced an immediate food shortage and crisis, extreme hunger and poverty (ECM, 2015). More surprisingly, the level of poverty and lower productivity are the main features of the focus regions about which most researchers do not give due attention to study it.

Most of the previous studies are failed to consider the fact that agricultural productivity (land or labor) is the most important determinants of the agricultural farm productivity at the national level or a more widespread in Ethiopia. Some of them are focused on district or zonal administrative level, and few of them are on the regional level. In addition, all are focused on the total factor productivity which is not appropriate enough to measure the wealth and living standards of the household; others are focusing on the income diversification. Therefore, our study tries to fill this gap by considering the *partial factor productivity measurement* to identify through which agricultural productivity indicators, the rural household agricultural productivity adversely changes in Ethiopia.

Least developed countries have shared common characteristics that determine for their backwardness and poor economic performance. The reason behind the low level of rural household income and agricultural productivity as well as failing to attractive investment opportunity is considered to be inadequate economic development in most of developing countries. But several attempts are made in Ethiopia through capital inflow like improved farm tools and equipment, and ensuring provision of financial services through the usual group lending methodology by local financial institutions to enhance the rural agricultural productivity and their household income. The significant agricultural sector productivity growth of the world mainly comes from the technological improvements. This has been proved in most Asian countries, but for countries like Ethiopia where the agriculture is the main livelihood for a rural area, the technology is enormous to enhance agricultural productivity. As the main income source of the rural household is highly susceptible to this sector, the overall rural household income will depend on the success or failure of agricultural productivity. Thus, measuring the status and identifying the determinants of agricultural productivity at small farm holder are very important. Thus, finding of this paper is very crucial to study the status and determinants of agricultural productivity in a rural household in Northern Ethiopia.

2. Literature Review

Agricultural productivity can be defined as the number of farm products produced by a household using the inputs needed in the agricultural sector in a specified geographical area (Fulginiti and Perrin, 1998). In a broad sense, it can be expressed as the ratio of the local monetary value of output to inputs used in the farm production (Olayide and Heady, 1982). However, agricultural productivity can be elucidated in terms of partial factor productivity that depends on the value of inputs applied in the production process. The first measure of agricultural productivity is called factor productivity (TFP), which is also explained as the ratio of agricultural outputs to agricultural inputs. The agricultural output is the overall values obtained as the sum of all components produced in the agricultural sector; whereas the agricultural input is the monetary value of the sum of all the inputs, such as fertilizer, pesticides, land, labor, machinery, and animals used for plow used in the farming activities.

Nevertheless, it is puzzling to combine diverse outputs and inputs into a single value rate to measure agricultural productivity (Ruttan, 2002). As a result, this technique is biased measure of productivity of inputs when input ratios change with advancement in technology without input changes (Gebreeyesus, 2006). Besides, markets also fail to function well in the case of aggregating output and input. For instance, only the well-functioning of the market for labor and land is used to value the rental and wages of their respective inputs accurately unless the measure of the TFP becomes obstinate. This idea is supported by Kelly *et al.* (1995) and finds that for the lack of timely and appropriate data in LDCs, like Africa, computations of the TFP are very challenging and made the analysis to yield a very biased result.

Due to these drawbacks, this study is considering the *partial* measure of agricultural productivity to address its objectives. Partial measures of agricultural productivity show the total monetary value of output produced per unit of scrupulous values of inputs used in the production process (Diewert and Nakamura, 2005). Practically, partial productivity analysis focuses on the partial productivity of land which measures the output per unit of land used and the partial productivity of labor which is stated as the output per economically active person utilized in the production process. Agricultural yield is typically used to evaluate the improvement of innovative production practice or changes in agricultural technology. The productivity of labor is mainly used for measuring and comparing the productivity of agricultural sectors within or across the rural households. Furthermore, for the capability and capacity, it has to reflect returns resulting from the sale of agricultural products, it is used as a welfare or standard of living measure for the rural households. To this end, measuring the partial productivity is a crucial point towards evaluating the welfare of the rural community. For example, per capita income is the most common measure of welfare, associated with the productivity of labor expressed as the value added per worker. In this case, determining the productivity of labor helps to well understand the situation of the living standards of nations (OECD, 2001).

Nevertheless, partial measures of productivity ratio have been challenged to consider all values of inputs utilized in the agricultural production process. But, deliberately and carefully developed partial measures are applied to evaluate outputs which are additions to differences in measured factors (Alston, Anderson, and Pardey, 1994). This study considers the

productivity of labor and land measures to evaluate the factors affecting them in the rural household.

Most production estimation models depend on the production function. This stochastic production function can be expressed using the common of the Cobb-Douglass production model and/or its log functional production form (Biggs, 2007; Zhang and Fan, 2001). This Cobb-Douglass farm production model is relatively an easy technique that is advantageous to capture multiple factors of production in its general form. Contrariwise, this model is challenged and poorly applied due to the restraint on the elasticity of substitution. Accordingly, the application of the translog functions is more sufficiently malleable to use since it allows us for the inference of various partial elasticity of substitution for any kind of inputs applied in the production process (Zhang and Fan, 2001). Resulting from its flexible on the elasticity of substitution and scale of economies, the Cobb-Douglass production function has both linear and quadratic functional forms which allow using more than two inputs (Kim, 1992). Since autocorrelation problem is evidenced in such model specifications, the goodness of fit of the model and diagnostic tests such as multicollinearity and heteroscedasticity are the basis to choose either cobb Cobb-Douglass and log functional(Ibid).

3. Methodology and Model Specification

The data for this research paper is a *panel data* survey of Ethiopian Rural Socioeconomic Survey (ERSS) which is carried out by Central Statistical Agency (CSA) and a team of the World Bank Living Standard Measurement Study (ISLM). The data was conducted in two rounds: in 2011/12 for the first time in Ethiopia in full sample coverage at the national level and the second round was conducted after two years later in 2013/14. The data focuses on household socio-economic features, agricultural production and demographic characteristics of households.

3.1. Data and Sample Design

The CSA (Central Statistical Authority) used two-stage probability sampling technique. At first selection, primary sampling units were carried out which are known as Enumeration Area(EA)s. A total of 278 centers were covered in the study, and proportionate sampling design was used to select the representative from the annual agricultural sample surveys in the regions.

The second stage was selecting representative households from the rural EAs. From each EA, a total of 10 households were randomly selected from the sample of 30 Annual Agricultural Sample Survey (AASS) households who are leading their life through farming and/or livestock. Further, two households were randomly selected from households who were not directly involved in agriculture during the first round of survey period in the rural EA. To utilize the data for this research work, the total sampled data is restricted only to regions located in the northern part of Ethiopia, which has similar farming, environmental, land holding, livelihood and poverty and food security features. Thus, based on the agriculture holder households, the 2,304 households were selected and 1197 households were fully covered in the first round. In the second round, only 1107 households have been surveyed for various reasons mainly availability of the households in their respective EAs and Farmer Association during the second survey period in the Northern region of the country. In this research

work, we dropped the observations which did not appear in the second round survey to make it balanced panel data. From this, 51.3 % of the sample households were from the Amhara region and the remaining 48.7 percent are from the Tigray region which is directly reflecting the application of proportionate sampling based on rural population size of the regions.

3.2. Description of the Study Area

The study area of the research rests in northern part of Ethiopia covering two regions which are really facing so many difficulties in terms of environmental issues and poverty situations. People of these two regions have practiced agriculture for many years and even it is believed that agricultural practices in the nation have been expended from these two regions. In their historical perspective, they were also serving as centers of government administration for a long time before King Menelik II has established modern Ethiopia in 1890. Further, despite the government has made supports to enhance the level of agriculture, but its productivity remains very poor for various reasons.

First, Amhara region is the third largest state, with an estimated area of 157,076.74 square km, located in the northwestern part of Ethiopia. It is bounded by the Afra, Benshangul Gumuz, Oromiya and Tigray regions in the east, southwest, south, and north, respectively, and Sudan in the northwest. Its population is 22 million as estimated in 2014. Its capital is Bahirdar, located on the shores of Lake Tana, a major tourist attraction, known for its very old monasteries and out of which the Blue Nile flows.

Second, Tigray is a region located in the northern most part of Ethiopia which is border by Eritrea in the North, Afar region by East, Amhara regional state from the South and Sudan in the West. Having Mekelle as a capital city of the region, the Tigray has an area of 84,721.77 km^2 and a population of 4,664,071. Of the total, 80.5 percent of the population resides in purely rural areas with an average population density of 55.1 per square kilometer (CSA, 2010).

3.3. Empirical Model for Agricultural Productivity Specification

A quantitative method was used to analyze the data. The log-linear of Cobb-Douglas production function of the within-group, the random effect (RE) and the fixed effect (FE) model were used to study the determinants of agricultural productivity in Northern Ethiopia.

Most of the studies using the Cobb-Douglas production function approach assume homogeneity and unitary elasticity of substitution between input and output. It is also among the best well-known production function utilized in applied production and productivity analysis (Enaami *et al.*, 2011).

Agricultural labor productivity levels are determined by many factors, which are mainly from the household's capacity and features, community and government support and other incentives. These factors have also been included in the assessments of agricultural productivity analysis (Hayami and Ruttan, 1985). However, the current analysis considers all the factors of production, such as the cultivated area of land, chemical fertilizer, number of oxen as a proxy for capital input, etc. Productivity will be measured based on the pure economic concepts set by Coelli *et al.* (2005). Let assume a small-holder farmer using N inputs, such as labor, seed, fertilizer, oxen power, to produce certain output level which is given by:

$$Y_{it} = \delta({L_{it}}^{\beta 1} K_{it}^{\beta 2}) e^{\mu_{it}} \quad (1)$$

where Y_{it} is the value of the i^{th} household's farm output in Ethiopian money(Birr) during period t,
L_{it} the i^{th} labor inputs used during period t,
K_{it} the i^{th} capital inputs at a time t,
μ_{it} the disturbance or error term,
$\beta 1 \; and \; \beta 2$ the output elasticity of labor and capital, respectively.

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

$$lnY_{it} = \beta_0 + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \mu_{it} \quad (2)$$

Therefore, in the case of our several dependent variables, the log-linear model would be given as:

$$\begin{aligned} lnY_{it} = {} & \beta_0 + \beta_1 lnAgriL_{it} + \beta_2 lnCaL_{it} + \beta_3 lnFaset_{it} + \beta_4 lnFerti_{it} + \beta_5 Oxen_{it} + \beta_6 Agehh_{it} \\ & + \beta_7 Sexh_{it} + \beta_8 Msh_{it} + \beta_9 Fs_{it} + \beta_{10} Eduh_{it} + \beta_{11} Crt_{it} + \beta_{12} Remi_{it} + \beta_{12} Irri_{it} \\ & + \beta_{13} lnArExt_{it} + \beta_{14} Assoc_{it} + \beta_{15} Pest_{it} + \beta_{15} Dmkt_{it} \\ & + \varepsilon_{it} \end{aligned} \quad (3)$$

Where:
lnY_{it} = the log of total farm output produced by i^{th} household during period t
$lnAgriL_{it}$ = the log of i^{th} household agricultural labor inputs during period t
$lnCaL_{it}$ = the log of the cultivated land area of the i^{th} household during period t
$lnFaset_{it}$ = the log of farm asset worth of the i^{th} household during period t
$lnFerti_{it}$ = the amount log of fertilizer used by i^{th} household during period t
$Oxen_{it}$ = the number of oxen used for plow by i^{th} household during period t
$Agehh_{it}$ = the age of the head of the family during period t
$Sexh_{it}$ = the sex of the i^{th} household head during period t
Msh_{it} = the marital status of the i^{th} household during period t
Fs_{it} = the family size of the i^{th} household during period t
$Eduh_{it}$ = the educational level of the i^{th} household head during the period t
Crt_{it} = the credit access for the i^{th} household during period t (dummy)
$Manri_{it}$= dummy whether the household i used manure in his land at time t or not
$Remi_{it}$ = having remittance support for the i^{th} household during period t (dummy)
$Irri_{it}$ = having access for irrigation for the i^{th} household during period t (dummy)
$lnArExt_{it}$ = having access for agricultural extension services for the i^{th} household during period t(dummy)
$Assoc_{it}$ = whether the HH is a member of any local association for the i^{th} household during period t (dummy)
$Pest_{it}$ = dummy whether the household i at time t used pesticide in his land or not
$Dmkt_{it}$ = the distance (kms) from the household i^{th} residence at time t to the common market place

From equation (3), it is possible to derive the partial productivity of the factors, or the *labor productivity*, and *land productivity*, by dividing both sides of equation (3) by the amount of labor force used in the agriculture and the cultivable area used, respectively.

Then, the *partial labor productivity* $\ln\left(\frac{Y}{AgriL}\right)$ is given by:

$$\ln(\frac{Y}{AgriL})it = \beta_0 + \beta_1 ln(\frac{AgriL}{AgriL})_{it} + \beta_2 ln(\frac{CaL}{AgriL})_{it} + \beta_3 ln(\frac{Faset}{AgriL})_{it} + \beta_4 ln(\frac{Ferti}{AgriL})_{it} + \beta_5(\frac{Oxen}{AgriL})_{it} + \beta_6 Agehh_{it} + \beta_7 Sexh_{it} + \beta_8 Msh_{it} + \beta_9 Fs_{it} + \beta_{10} Eduh_{it} + \beta_{11} Crt_{it} + \beta_{12} Remi_{it} + \beta_{12} Irri_{it} + \beta_{13} lnArExt_{it} + \beta_{14} Assoc_{it} + \beta_{15} Pest_{it} + \beta_{15} Dmkt_{it} + \varepsilon_{it} \quad (4)$$

Similarly, we will have aggregated output per cultivated area of land as a measure of land productivity, and will give us the *partial land productivity* $\ln\left(\frac{Y}{CaL}\right)it$ which is also represented by:

$$\ln(\frac{Y}{CaL})it = \beta_{0i} + \beta_1 ln(\frac{AgriL}{CaL})_{it} + \beta_2 ln(\frac{CaL}{CaL})_{it} + \beta_3 ln(\frac{Asset}{CaL})_{it} + \beta_4 ln(\frac{Fer}{CaL})_{it} + \beta_5(\frac{Ox}{CaL})_{it} + \beta_6 Ageh_{it} + \beta_7 Sexh_{it} + \beta_8 Msh_{it} + \beta_9 Fs_{it} + \beta_{10} Eduh_{it} + \beta_{11} Crt_{it} + \beta_{12} Remi_{it} + \beta_{12} Irri_{it} + \beta_{13} lnArExt_{it} + \beta_{14} Assoc_{it} + \beta_{15} Pest_{it} + \beta_{15} Dmkt_{it} + \varepsilon_{it} \quad (5)$$

There are three panel data regression models used in this study: (i) the within-group estimation method, (ii) the random effect, and (iii) the fixed effect model. To estimate labor and land partial productivity, or for equation (4) and (5), since we used the panel data, the panel data regression model is represented as:

$$Y_{it} = \vartheta_{it} + \beta X_{it} + U_{it} \quad i = 1,2,\dots,N \text{ and } t = 1,2,\dots,T$$

where Y_{it} denotes dependent variable, X_{it} independent variable, ϑ_{it} unobserved individual heterogeneity or the individual fixed effect, β parameter to be estimated and U_{it} residual.

4. Empirical Results

This section focuses on the econometric analysis to estimate determinants of agricultural output, labor productivity and land productivity.

4.1. Total Agricultural Productivity

In this chapter, an econometric analysis of the determinants of agricultural productivity in Northern Ethiopia using the panel data is the main objective. In particular, both the labor productivity and the land productivity are going to be addressed. The variables considered are the household variables, community variables, access to social services, administrative distances and access for infrastructure. The relationship between the dependent variable, or *log of total value product*, and different explanatory variables are presented in Table 1. Among the explanatory variables only log distance from administrative zone (1%), having land ownership certificate (1%), log distance from market

(5%), log of number of labors used (5%), getting remittance of different forms (5%), gender and age of the family head are statistically significant to influence the total product at 10 %, where the parentheses are the significance level.

Table 1. Pooled OLS on the Total Agricultural Productivity

Log Total Product	**Coeff.**	**T**	**P>t**	**[95% Conf.**	**Interval]**
Log fertilizer used(Kgs)	-0.071	-1.270	0.203	-0.181	0.038
	(0.056)				
Log asset value	-0.008	-0.440	0.663	-0.043	0.027
	(0.018)				
Log cultivable land	0.034	0.800	0.425	-0.049	0.116
	(0.042)				
Log number of labor	0.052**	2.250	0.025	0.007	0.098
	(0.023)				
hh_size	0.001	0.080	0.937	-0.017	0.018
	(0.009)				
Health problem (yes=1)	-0.065	-1.290	0.198	-0.164	0.034
	(0.050)				
Extension (yes=1)	0.024	0.570	0.572	-0.058	0.106
	(0.042)				
Log distance from market	0.129**	2.500	0.013	0.028	0.231
	(0.052)				
Log distance from zone	-0.143***	-2.970	0.003	-0.238	-0.049
	(0.048)				
Distance from farm to home	0.003	0.140	0.888	-0.043	0.050
	(0.024)				
Read and write (yes=1)	0.019	0.420	0.671	-0.068	0.105
	(0.044)				
Land certificate (yes=1)	0.169***	3.120	0.002	0.063	0.275
	(0.054)				
Member of association (yes=1)	-0.050	-1.220	0.225	-0.131	0.031
	(0.041)				
Gender of head (male=1)	0.107*	1.930	0.054	-0.002	0.215
	(0.055)				
Age of head	-0.003*	-1.760	0.079	-0.007	0.000
	(0.002)				
Oxen	-0.002	-0.190	0.847	-0.024	0.019
	(0.002)				
Pesticide used (yes=1)	-0.071	-1.400	0.163	-0.172	0.029
	(0.051)				
Safety net (yes=1)	0.020	0.470	0.638	-0.062	0.101
	(0.042)				
Remittance (yes=1)	0.176**	2.290	0.022	0.025	0.326
	(0.077)				
Shocks (yes=1)	0.022	0.350	0.729	-0.102	0.145
	(0.063)				
_cons	8.095***	18.740	0.000	7.247	8.944
	(0.432)				
Number of Observ.	2139	2139	2139		

F(20, 1032)	2.19
Prob > F	0.002
R-squared	0.0471
Adj R-squared	0.0256
Root MSE	0.60745

Note: *** denotes significant at 1%, ** is at 5% and * is at 10%.

In this pooled regression result, even if they are significant, some variables have an unexpected sign. For instance, utilization of fertilizer by the farmer is expected to increase the productivity, but has a negative sign. Of course, there are studies which show the negative effect of fertilizers. The simple pooled OLS is exposed to different errors, and thus the estimators are really biased.

In fact, the objective of the result is to see the correlation between the variables whether they have the expected sign or not. Moreover, though they are insignificant, most of the variables have the desired sign. In fact, the fertilize utilization at the household level is expected to be determined not only by the farmers' access for fertilizer, but also by the proper amount utilization, time of utilization, rain situation, type of soil and other factors. These all factors can affect the utilization of fertilizer and cause the productivity to be negative for its miss-treatment.

To solve the intended problems on the pooled OLS estimation and to measure the productivity of labor and land, the utilization of the fixed effect, random effect and the within estimation techniques of panel data have been done and the results are presented as follows.

4.2. Land Productivity

The productivity of land is measured by the total product per cultivable land used in a hectare and affected by household variables, community-level factors, access to farm technologies, seeds, chemicals and others. In this part, we have tried to analyze the land productivity and the details are presented below. To decide the estimation model fitting this analysis and to interpret the results, Hausman test and F-test were employed. Based on the F-test ($F(17,89) = 5.66$) from the fixed effect estimation, we reject the null hypothesis and favor to use the fixed effect estimation. Thus, the null hypothesis of groups with a common intercept has been rejected and this confirms the use of the fixed effect. In addition, using the Hausman test, the p-value favors using random effect since we accept the null hypothesis of differences in coefficients.

Further, Breusch and Pagan LM test for random effects carried out to make a decision on the pooled OLS and the random effect. Therefore, the p-value result indicates to use the random effect rather than the pooled OLS. As a result, the explanation and interpretation of the estimates are based on the random effect model.

Table 2. Determinants of Land Productivity[1]

	Pooled OLS	**Fixed Effect**	**Random Effect**
Log asset per land	0.0505**	0.0577	0.0518**
	(0.017)	(0.040)	(0.017)
Log fertilizer per land	0.6549***	0.5339***	0.6515***
Log labor per land	0.1512***	0.0888	0.1491***
	(0.027)	(0.065)	(0.027)
Oxen per land	0.0123**	0.0293	0.0125**
	(0.004)	(0.017)	(0.004)
Age of head	-0.0060*	-0.0055	-0.0059*
	(0.003)	(0.005)	(0.002)
Education of head	0.0005	-0.0142	-0.0010
	(0.021)	(0.053)	(0.021)
Gender of head	0.0394	0.1732	0.0416
	(0.066)	(0.167)	(0.066)
Pesticide	-0.1101	-0.4266**	-0.1145
	(0.059)	(0.136)	(0.059)
Safety net	-0.0491	-0.3559	-0.0491
	(0.077)	(0.180)	(0.077)
Remittance	0.0328	-0.1322	0.0280
	(0.089)	(0.195)	(0.089)
Shocks	-0.0414	-0.4356*	-0.0448
	(0.078)	(0.196)	(0.078)
Irrigation	0.0167	0.0125	0.0164
	(0.055)	(0.132)	(0.055)
Household size	-0.0001	0.0147	-0.0006
	(0.011)	(0.027)	(0.011)
Health problem	0.0381	0.3454*	0.0414
	(0.060)	(0.152)	(0.060)
Member of association	-0.0565	-0.1799	-0.0609
	(0.049)	(0.115)	(0.048)
Credit	-0.2533***	-0.4342**	-0.2542***
	(0.063)	(0.140)	(0.063)
Extension	0.0989*	-0.0131	0.0969*
	(0.049)	(0.125)	(0.049)
R-sq		-0.1387	0.3990
Prob > chi2		0.0000	0.0000
corr(u_i, X)		0 (assumed)	0 (assumed)
sigma_u		.734	.203
sigma_e		.679	.679
rho		.539	.082
N	2139	2139	2139

F(17,989) = 5.66

1. Fixed effect: F test that all u_i=0: F(742, 137) = 1.13 Prob > F = 0.1840
2. Breusch and Pagan LM test for random effects:
   ln product land [id,t] = Xb + u[id] + e[id,t]

	Var	sd = sqrt(Var)
ln produ~d	0.82	0.81
e	0.46	0.679
u	0.042	0.20

[1] To check the external influences, like heteroskedasticity problem and multicollinearity issues, the model has been passed through all the possibilities; the correlation matrix and all variables are free of the problem. The heteroskedasticity problem has been checked using the VIF as well as the Wald test. Moreover, to be in a safe position, we used robust standard error in the estimation.

Note 1: Values in brackets are robust standard errors.
Note 2: * denotes $p < 0.05$, ** is $p < 0.01$ and *** is $p < 0.001$.

Land productivity in Northern Ethiopia is affected by access to credit, agricultural extension services, family head's age, owning oxen, fertilizer used and farm asset of the household. The significant variables have the expected sign of influence except for the credit service. Access to credit services is hypothesized to affect positively as it helps farmer's money shortage during the planting and harvesting seasons and fills other effects of the household. However, if the credit money is used for other purposes beyond the expected purpose, it will definitely have an adverse effect on the livelihood of the household and this leads to negatively affect the productivity. In another way round, the small number of beneficiaries of this credit service might also have an influence on this situation as only 26 percent of the households have the access.

One important finding of this paper is the utilization of fertilizer: it has significant positive value to impact on land productivity. A one percent increase in a fertilize use increases the productivity of land by 0.65 percent which is statistically significant at 1%. The other factor affecting the productivity of land is the credit access that households have. In fact, the beneficiary households are very small since the amount they took, the investment they made using this money, and the level of allocation of this money are not included in the survey. This hinders to make a strong concluding remark about this. What so ever, it signifies the misallocation of credit funds to unproductive activities, and this implies that if the beneficiary households used the credit money in areas which do not help to enhance the productivity of land and invest in other unproductive investments, its contribution to land productivity may be very insignificant and can be negative as households are going to refund the money and can be fully liable to the amount of the loan. Therefore, compared to non-beneficiaries, households having credit access have 0.25 percent lower land productivity that is statistically significant at 1 % level. The share of labor per land is evidenced to be statistically significant at 99 confidence level. A one percent increase in the labor per land leads to 0.15 percent increase in productivity of land in Northern Ethiopia. This result is in line with most of the findings focusing on determining the productivity of agricultural land.

The second class of significant (5%) variables includes the log asset per land and the oxen per cultivated land. Thus, 1% increases in the value of asset per land increase the productivity of land by 0.05 percent; and one percent increase in a number of oxen per land used also increases the productivity of land by 0.012 percent.

In addition, access for the different agricultural extension packages and the age of the family head are also statistically significant (10%) to determine the agricultural productivity. The age of the household head negatively affects agricultural productivity. A one percent increase in the age of the head declines the agricultural land productivity by 0.01 percent. This finding is against to the hypothesis that productivity has increased with age since the farmer can accumulate wealth which influences land productivity and the experience by itself is also a lesson to utilize the land more than those who have less farming experiences. However, this might not be always true. This might support the other class of ideology concerning age. As age increases, the power of the farmer declines and farming activities at old ages are really challenging as it demands more power to cultivate the land and to work more hours of hard work. In the northern part of the Ethiopia, because of the high level of poverty resulting from repeated drought, health problems, lack of quality of food, the slow working

situation mainly due cultural and religious holidays, especially by the old people, the average aged man will not work and spend the time and energy he is expected to invest on his plot of land which made his land to remain less productive. When we see the age structure of the households, 45 percent of the households are having an age of less than the mean age of the heads. This shows that there is a possibility of young family heads who expected to work hard and increase the productivity of the land. However, as they are relatively younger to participate in off-farm activities, their participation in their land remains very limited. Especially, those who depend on rain feed would wait to cultivate their land for very few days and this forced their land to remain poor. This is highly evidenced that around 48 percent of the households have supplementary employment in other sectors of the economy.

In addition, as those who are involved in the additional works to generate income are male-headed households, definitely, in their absence, their agricultural practices will be influenced. These all ensure that the negative effect of age on land productivity might able to explain the situation in Northern Ethiopia.

Households having an access to agricultural packages and extension services are having better achievements in their land productivity. The supports in kind and advisory are the inputs for their positive contribution to productivity. Thus, compared to the households who do not have access to the extension services, beneficiaries have 0.097 percent higher land productivity.

4.3. Labor Productivity

Socioeconomic, household, and community level variables will influence the productivity of labor. Our explained variable here is the log average product of labor used in the agricultural sector and a set of explanatory variables were included. To interpret the coefficients, a decision is required for which type of the panel data model fits for this data set. As a result, different tests have been carried out and the comparison between the pooled OLS and the fixed effect supports the pooled OLS as the F-statistics of the fixed effect model is insignificant. Thus, we initiated to accept the null hypothesis of group intercepts. In the same idea stated above, the Hausman test also supports the appropriateness of the random effect and all the analyses are based on the random effect estimation. Six variables are found to be statistically significant to determine the productivity of labor in Northern Ethiopia. Moreover, log land per labor, log fertilizer per labor and credit access are statistically significant at 1% level, and utilizing pesticide, oxen per labor and age of the household head are also statistically significant at 10 % significance level.

Table 3. Labor Productivity using Pooled OLS, Fixed and Random Effect

	Estimates		
	Fixed effect	Random effect	Pooled OLS
Log land per labor	0.3108**	0.2245***	0.2236***
	(0.100)	(0.042)	(0.042)

Age of the family head	-0.0088	-0.0063*	-0.0064*
	(0.005)	(0.003)	(0.003)
Education of level of head	-0.0542	-0.0096	-0.0087
	(0.060)	(0.022)	(0.022)
Log asset per labor	0.0611	0.0390	0.0375
	(0.058)	(0.020)	(0.020)
Log fertilizer per labor	0.4977***	0.5469***	0.5474***
	(0.134)	(0.050)	(0.049)
Oxen per labor	0.0144	0.0361*	0.0365**
	(0.017)	(0.014)	(0.014)
Gender of the head	0.2578	0.0498	0.0461
	(0.193)	(0.070)	(0.070)
Pesticide	-0.4465**	-0.1586*	-0.1552*
	(0.165)	(0.072)	(0.072)
Safety net	-0.3348*	-0.0579	-0.0598
	(0.158)	(0.079)	(0.079)
Remittance	-0.2608	0.0695	0.0809
	(0.179)	(0.088)	(0.088)
Shocks	-0.3630	-0.0763	-0.0765
	(0.198)	(0.081)	(0.080)
Irrigation	0.0649	0.0115	0.0129
	(0.147)	(0.053)	(0.053)
Family size	-0.0034	-0.0017	-0.0009
	(0.034)	(0.011)	(0.011)
Health problem	0.0608	-0.0190	-0.0187
	(0.209)	(0.063)	(0.062)
Member of association	-0.1657	-0.0386	-0.0352
	(0.122)	(0.050)	(0.050)
Credit access	-0.3925*	-0.3458***	-0.3486***
	(0.200)	(0.075)	(0.074)
Extension	0.0987	0.0719	0.0729
	(0.126)	(0.052)	(0.051)
_cons	6.5193***	5.1647***	5.1486***
	(0.835)	(0.370)	(0.373)
R-sq	0.748	0.716	
Prob > chi2	0.0000	0.0000	
corr(u_i, X)	-0.1405	0(assumed)	
sigma_u	0.708	0.214	
sigma_e	0.659	0.659	
rho	0.535	0.095	
N	2139	2139	2139

Fixed effect test F(17,989)=15.53
F-test that all u_i=0: F(672,989) =1.11 Prob >F=0.2704

Note 1: Standard errors are robust and in parentheses.

Note 2: * is $p < 0.05$, ** is $p < 0.01$ and *** p is < 0.001

As indicated in Table 3, one percent rise in the cultivable land per unit of labor used increases the productivity of labor by 0.2245 percent. Credit access is also affecting the labor productivity negatively. Households having the access to credit facilities at their locality have 0.35 percent lower labor productivity than their counterpart. This might be because of the reason why households took the credit and whether they invest it in more related activities which enhance the productivity of labor or not. In addition, in most cases, in rural Ethiopia, as the credit facilities are provided on group lending basis, the amount of loan for the first customer might not be greater than $100. This money might be less to bring the desired change if the household is a first customer (Yibrah *et al.*, 2014).

The other significant factor is the fertilizer used per labor which signifies its positive relationship. It is a statistically significant factor to increase the label of labor productivity at 1% level of significance. That is, a one percent increase in utilization of fertilizer per labor enhances the productivity of labor by 0.56 percent which is very significant positive change. The third variable which remains significant at the top extreme level significance is the log of labor per land.

The second class of variables is statistically significant at 1% is the utilization habit of pesticides to their farmland, oxen per labor and the age of the head of the household. A unit increase in the plow oxen leads the productivity of labor to increase by 0.34 percent. In the study area, oxen are used mostly for plowing land purpose and household needs to own an ox to strengthen their agricultural practices and to become more productive. If they do not have oxen, they are expected to borrow if those who own do not use them: that is, unless they rent their land for the fixed sum of money and/or used for sharing the product based upon their agreed scheme.

The pesticide utilization variable is found to be significant, but it has an opposite sign to the hypothesis. Households who were using pesticides at their farm have 0.16 percent lower labor productivity than the others. In this study, 60 percent of the household have used pesticide at their farmland and the concern of small observation is not valid, but as there are different types of pesticides both from the local and imported products, households might face difficulties to differentiate which one is good and bad. They might also face challenges on the utilization of the chemicals as a significant number of the households would not read and write and those who are considered as literate also will face language barriers with the imported products. Especially, when the product is introduced for the first time, it is very challenging for farmers to take lessons from their friends and the contribution of the professionals is mostly insignificant as their number is very small. Thus, if they could not get one who helped them how to use, definitely, the effect might be devastating as chemicals are toxic and have adverse effects on livestock, grass, crops, and health, as well.

For reasons stated above, the effect of age of the head on land productivity is also found inversely. A one year increase in age reduces the average productivity of labor by 0.006 percent. In fact, the magnitude is very small compared to the coefficient of the other variables.

5. Conclusion

Our objective is to analyze the status and determinants of agricultural productivity in Northern Ethiopia by focusing on the labor and land productivity. In doing so, we used two-year panel data. Using the data collected by Central Statistical Authority of Ethiopia and the World Bank Welfare Group with the sample of 2214, we estimated the fixed effect, the random effect and the pooled OLS.

The pooled OLS estimation on the determinants of total agricultural productivity in Northern Ethiopia revealed the following results: log distance from administrative zone (1%), having land ownership certificate (1%), log distance from market (5%), log of number of labors used (5%), getting remittance of different forms (5%), gender and age of the household head (10%) are affecting total agricultural productivity in Northern Ethiopia.

As Hausman test supports for the appropriateness of the random effect, the determinants of the labor and land productivity were estimated by using it. The *partial productivity* of land and labor has been affected by demographic features, the community variables, and accesses. First, *land productivity* in Northern Ethiopia is affected by access to credit (1%), agricultural extension services(10%), age of the family head (10%), ownership of oxen (5%), fertilizer used (1%) and farm asset of the household (5%). Second, *labor productivity* is influenced by land per labor, fertilizer per labor and credit access. These are statistically significant at 1% significance level. Moreover, the utilizing pesticide, oxen per labor and age of the household head are also statistically significant at 10 % significance level.

This study has tried to identify the status and determinants of agricultural productivity in the small farm holder in Northern Ethiopia. Based on the estimation results obtained from the study, we suggest the following point to be addressed: to increase the agricultural productivity of farm households in Ethiopia, then strengthening the utilization of labor and land, utilization of fertilizers, and increasing access for agricultural extension services and irrigation practices are urgently demanding.

Despite the information that households have about the access for different credit facilities, their utilization rate is very low and its contribution to enhancing both the labor and the land productivity is negative but significant. This might be due to the fact that households have not been using the money for the productive purpose. The provision of the credit and the amount of money might be small enough to build the productivity of land and labor as much as possible. Thus, increasing the schemes of credit facilities and the amount of loan, encouraging households to take loans and help households to be aware of how to spend their money at large would help to enhance the productivity of land and labor at household level.

The other point which needs great attention is the utilization of pesticides. As pesticides have different side effects or external effects, the understanding and knowledge for the proper utilization are highly required. Misuse and improper mix will lead to affect the productivity to be slow down and even influence in the reverse direction. Thus, the government concerned should help farmers to increase their awareness of the proper utilization of the pesticides.

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