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Smallholders' technical efficiency of teff production in Ethiopia

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The main objective of this study is to examine the level and determinants of technical efficiency of smallholder Teff producers in Ethiopia using Stochastic Frontier Analysis (SFA), with appropriate production function, trans-log by LR test. Secondary data from Ethiopian socio-economic survey were used for the analysis. The result of Maximum likelihood Estimate (MLE) shows that area, fertilizer and fragmentation of land are major factors that influence productivity, and output elasticity has positive response on area, labour and fertilizer inputs. The average estimated technical efficiency of small holder farmers ranges from 0.13 to 0.92%, with mean efficiency of 73%. This implies that Teff productivity can be increased by 27% at existing level of technology. The result also shows there is inefficiency in production of Teff since discrepancy ratio gamma, γ is high and about 0.85. The study also identified that agro-ecology zones, age, extension, seed type, other income are the major socio economic factors influencing efficiency. Finally, the study recommends that policy geared towards the enhancement of productive efficiency of smallholder, through the appropriate consideration of inputs, socio economic factors and other facilities are important to address problem of food insecurity in Ethiopia.

Key words: Teff, technical efficiency, stochastic frontier, agro-ecological zone, maximum likelihood estimate, Ethiopia.

INTRODUCTION

In developing countries, agriculture (farming or livestock) is the main source of income, foreign exchange, and job opportunities. In Ethiopia, it generates about 45% of GDP, more than 50% foreign exchange, and about 80% of jobs. Thus, it is the central concern of government policy makers and also practiced by 98% of the rural households, 61% of the small town households and 13% of large town households (WB, ESS Report 2013/2014).

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For most developing countries, enhancing the total production and productivity is not an option rather it is a necessity and the first concern in their policies. Production and productivity basically can be enhanced using two methods. The first method is through increased use of inputs and/or improvement in technology at certain level of input. The other option is to develop the efficiency of producers or farmers (Wassie, 2014).

Measuring efficiency provides a way of quantifying and comparing the performance of each farmer, and identification of factors explaining any inefficiencies and differences in performance. Identification of factors affecting inefficiency can assist stakeholders in the improvement of productivity to identify controllable and uncontrollable factors affecting efficiency that need to be taken into account in designing interventions. Improving efficiency in production allows farmers to increase their output without additional inputs and changing production technologies resulting in increased productivity (Bravo-Urea and pithier, 1997). For smallholder farmers, variations in productivity due to differences in efficiency may be affected by various regional and farm specific socio-economic factors. In order to identify these factors, there is a need to find a way of representing the performance of the farmers.

Teff is one of the major cereal crops in Ethiopia which is basically produced and for food consumption. The composition of Teff has good mineral content and generally higher amount of the essential amino acids that are important for health. The crop can grow well in moisture stress and waterlogged conditions better than other cereals (Engdawork, 2009). For local consumption Injera (Ethiopian Injera, a soft pancake, baked from fermented batter, is preferentially prepared from Teff as cited by Fischer et al., 2014), made from Teff is the favorite diet of the citizens and usually considered as a prestige in Ethiopia. For consumers, its taste and preference is unique making other grains the poor substitute for Teff. These reasons have led the demand for Teff to consistently increase over time and its demand is inelastic to price variability compared to other grain crops in Ethiopia. The annual volume of production had increased from 16, 773,480 in 2003/04 to 47,506,572.79 quintals in 2013/2014, with average annual growth rate of 15.8%. It has also an excellent resistance to moisture stress, suitable to multiple cropping and not easily attached by weevils and other pests can store it for long period of time (CSA, 2013/14).

The core goal of this study is therefore to examine the level of technical efficiency of smallholder Teff producers in Ethiopia. Specifically, this paper attempts to determine efficiency and mean efficiency levels of smallholder Teff producer farmers in Ethiopia; identify some socio-economic factors which influence efficiency level of Teff production; determine production function inputs elasticity; yield gap from maximum or frontier output of Teff production; and suggest what incentive and policy measures has been taken to improve technical efficiency farmer's productivity and closing yield gap based on the result.

METHODOLOGY

The data used for the study are drawn from the Ethiopian Socio-economic Survey (ESS), collected in a collaboration project between the Central Statistics Agency of Ethiopia (CSA) and the World Bank Living Standards Measurement Study-Integrated Surveys of Agriculture (LSMS-ISA), carried out in 2013/2014. The study applied both descriptive statistics and econometrics models. Econometrics models include the Frontier model under MLE used to estimate the parameter of the production function, TE, and each mean efficiency score of the household. Furthermore, the inefficiency model determines inefficiency effect on Teff production. The study used STATA12 and FRONTIER 4.1 for testing hypothesis, data manipulation and analysis.

Stochastic frontier models (SFM) of production frontier developed simultaneously by Aigner et al. (1977) and Meeusen and van den Brock (1977) are made up of three components; the deterministic production function, the idiosyncratic error and the inefficiency error component. Since the error term has two components, the stochastic frontier models are often referred to as 'composed error models'. The general version of the stochastic frontier production function model can be written as follows:

$Y_i = f(x_i, \beta) \exp(v_i) \exp(u_i)$, i = 1, 2, 3, … I, or $Y_i = f(x_i, \beta) + \varepsilon_i$

$Yi = \beta_0 + \beta_1(AREA) + \beta_2(AMLABOUR) + \beta_3(QCFERT) + \beta_4(AMFLD) + \beta_5(FSIZE) + +v_i + ui$

x_1 Farm size or area per hectare
x_2 Amount of labour (man-days)
x_3 Quantity of chemical fertilizer used
x_4 Amount of fragmentation of land households have in 2013/14
x_5 Family size of household

Where, is Y_i is the output of the i^{th}farmer; is x_i is a vector of farm inputs; β is a vector of parameters to be estimated; while v_i measures the random variation in output Y_i due to factors outside the control of the farm, u_i are factors within the control of the farm responsible for its inefficiency. v_i is assumed to be identically and independently distributed as N $(0,\delta_v^2)$ and independent of u_i which has a half-normal $u \overset{iid}{\sim} N^+(0,\delta_u^2)$ and truncated.
u_i^{iid}_ $N(\mu, \delta_u^2)$) of non-negative distribution, |u| for this study and also independent of each other.
The essential factor in the stochastic frontier model is the composed error term ε (Aligner et al.,1977) defined as, $\varepsilon = v_i - u_i$, =,the v_i the two side error term capture stochastic effect outside control of farmers and u_i one side $u_i \geq 0$ 0 error capture technical inefficiency of farmers. Jondrow et al. (1992) specified a decomposition method from the conditional distribution of ui given ε.

Technical efficiency is measured as a ratio of actual to potential output (Aigner et al., 1977; Meeusen and van den Broeck, 1977) independently developed as cited (Coelli et al, 2005) as:

$$TEi = \frac{yi}{y^*} = \frac{yi}{\exp(x'i, \beta) + vi} = \frac{\exp(x'i, \beta + vi - ui)}{\exp(x'i, \beta) + vi} = \exp(-ui)$$

Where$y$*, (*, y_i)are potential and actual output respectively. The technical efficiency of a farmer, is predicted using the frontier program, which calculates the maximum likelihood estimators, is between 0 and 1 and is inversely related to the level of the technical inefficiency effect. For instance, if output is measured in logarithms, the farm specific technical efficiency can be estimated as:

TE = $\exp^{-u}$ = $z_i\delta$ i= 1, 2...n, 0≤ TE ≤1

Where i refers to the i^{th} farmer, z_i represents the vector of firm specific factors determining inefficiency. δ stands for the unknown parameters to be estimated together with the variance parameters expressed as:

$\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2) = \sigma_u^2/\sigma^2$

The variance ratio γ, explains the total variation in output from the frontier level of output attributed to technical inefficiencies. And it has a value between zero and one, such that the value of zero is associated with the non-negative random variable, ui is absent from the model. The parameters, $\beta, \delta, \sigma_u^2, \sigma_v^2$, and γ can be estimated by method of maximum likelihood using the computer program, Frontier 4.1 (Coelli and Battese, 1996).

farm specific technical efficiency is defined by,

$TEi = E\{exp - {}^{u_i}/_{\varepsilon_i}) = \frac{(1-\phi[\delta_{ui}^* + \gamma\varepsilon i/\delta_{ui}^*]}{(1-\phi\left[\frac{\gamma\varepsilon i}{\delta_{u_i}^*}\right])} exp\ \gamma\varepsilon i + \frac{1}{2}\delta_u^* 2,$ ϕ

cumulative function of standard normal variable $\gamma = {}^{\delta_u^2}/_{\sigma}$ $\sigma = \sigma_u^2 + \sigma_v^2$, $\delta_u^* = \sqrt{\gamma(1-\gamma)\delta_\varepsilon^2}$ is the estimated parameter of conditional distribution, ui/ε. The mean TE of farm in the system given as.

$$TE = \left\{\frac{1-\phi\left[\sigma + \left(\frac{\mu}{\sigma}\right)\right]}{1-\phi\left(\frac{\mu}{\sigma}\right)}\right\} \exp(\mu + 1/2\sigma^2)$$

Technical inefficiency model proposed by Battese and Coelli (1995) revised (2005) technical inefficiency (TI) effect defined as, $u_i = z_i\delta + w_i$,

Vector explains weather households live in Kola, Dega ,Woyina

$$ui = \delta_0 + \delta_1(KOLLA) + \delta_2(DEGA) + \delta_3(WDEGA) + \delta_4(AGEH) + \delta_5(EXTENSION) + \delta_6(SEEDTYPE) + \delta_7(SEXH) + \delta_8(EDUCATION) + \delta_9(OTHERINC) + \delta_{10}(CREDIT) + wi$$

dega ecological zone; category of age of household heads; applies extension program on field, types of seeds improved or not; sex of heads of households; category of educational level; sources of households' income other than their agricultural outputs; whether households get credit service for agriculture. Zi's is $(1xm)$ vector of explanatory variable associated with technical inefficiency effect, δ is an $(mx1)$ vector of unknown parameter to be estimated and wi unobservable random variable. The parameters indicate the impacts of variables $Z_i$on TE. A negative value suggests a positive influence on TE and vice versa.

The parameters of the stochastic frontier and the inefficiency model are estimated simultaneously, given appropriate distributional assumptions associated with cross- sectional data on the sample firms. To compute technical efficiency, MLE is used because an arguably better solution is to make distributional assumptions concerning two error terms and the estimate model using ML, has desirable large sample (that is asymptotic) properties; they are often preferred to other estimators such as corrected ordinary least square estimation (Coelli et al., 2005).

In terms of the functional form of the SFM, the two commonly used are Cobb-Douglas and the trans-log. The main advantage of the trans-log is that it is flexible, and does not impose assumptions about constant elasticity of production nor elasticity of substitutions between inputs. But, it can cause Multi-colinearity problems (Dawson et al., 1991). The generalized likelihood ratio (LR) test is used to ascertain the appropriateness of the use of either the Cobb-Douglas or the trans-log functional form and for other hypothesis testing to determine the relationship between Teff output (dependent variable), socioeconomic and farm-specific factors (explanatory variables).

General formula for Cobb-Douglas and Trans-log is given as:

Cobb-Douglas, $lnyi = \beta_0 + \beta_k \sum lnx_k + \varepsilon i$, $\forall i$
Trans-log production function,

$$f(xi,\beta) = \exp(\beta_0 + \sum_{k=1}^{k} \beta_k \, logx_k + 1/2 \sum_{k=1}^{k} \sum_{l=1}^{k} \beta_{kl} \, logxklogxl) + \varepsilon_i$$

In both cases β_0 is a constant term and restrictions on the technology parameters are usually imposed in order to ensure that $f(xi;\beta)$is homogeneous of degree not greater than one to rule out the possibility of increasing return to scale (Porcelli, 2009). For Cobb-Douglas production function becomes,

$$lnYi = \beta_0 + \beta_1 lnx_{1+}\beta_2 lnx_2 + \beta_3 lnx_3 + \beta_4 lnx_4 + \beta_5 lnx_5 + vi - ui$$

In Trans-log production function is,

$$lnYi = \beta_0 + \beta_1 lnx_{1+}\beta_2 lnx_2 + \beta_3 lnx_3 + \beta_4 lnx_4 + \beta_5 lnx_5 + 0.5(\beta_{11} lnx_1^2 + \beta_{22} lnx_2^2 + \beta_{33} lnx_3^2 + \beta_{44} lnx_4^2 + \beta_{55} lnx_5^2) + \beta_{12} \ln x_1 lnx_2 + \beta_{13} \ln x_1 lnx_3 + \beta_{14} \ln x_1 lnx_4 + \beta_{15} \ln x_1 lnx_5 + \beta_{23} \ln x_2 lnx_3 + \beta_{24} \ln x_2 lnx_4 + \beta_{25} \ln x_2 lnx_5 + \beta_{34} \ln x_3 lnx_4 + \beta_{35} \ln x_3 lnx_5 + \beta_{45} \ln x_4 lnx_5 + \varepsilon_i$$

ln Natural logarithmic function
yi Amount of Yield of production of Teff in quintal
β_0 Constant value
β_i Parameter to be estimated
x_1 Farm size or area per hectare
x_2 Amount of labour (man-days)
x_3 Quantity of chemical fertilizer used
x_4 Amount of fragmentation of land households have in 2013/14
x_5 Family size of household
ε_i Composed Error component

The first order coefficients of the above trans-log function are not considered as they are not very informative, and an alternative determination of elasticity becomes necessary for estimation of responsiveness of yield to inputs. Output elasticity calculated as variable means are important in this case (Awudu and Eberlin, 2001) as cited by Susan (2014).The elasticity of output e_i with respect to i^{th} input is calculated as;

Table 1. Explanatory variables with expected sign.

Variable	Measurement	Expected sign
Yield of Teff	Amount of Teff produced(quintal/hec)	
Production function		
X1= farm size (Area)	Total area used for Teff production in hectare	+
X2= Labour	Amount of Labour used per days	+
X3=fertilizer	Quantity of chemical fertilizer used in kilo gram	+
X4=field	Amount of fragmentation of land have	_
X5=family size	Total household members	+/-
Inefficiency model		
Z1=KOLLA	Dummy and categorical variables	+
Z2=DEGA	Household live in Kola agro-ecology zone=1	-/+
Z3=WDEGA	Dega agro-ecology zone,=1	-
Z4=AGEH	Woyina dega agro-ecology zone,=1	-
Z4=EXTENSION	Category of Age of household head	-
Z5=SEEDTYPE	Apply extension program on field=1	-
Z6=SEXH	Type of seed improved=1	-
Z7=EDUCATION	Male headed of household,1	-
Z8=OTHERINCOM	Category of Educational level	-/+
Z9=CREDIT	If household got income other than their agricultural output=1, If household got credit service for agriculture,=1	-/+

$$e_i = \frac{\partial lnY}{\partial lnxi} * \frac{x_i}{Y} = \beta_i + \beta_{ii} ln\bar{x}_i \sum_{j \neq i} \beta_{ij} \; ln\bar{x}_j$$

That is for area output elasticity can be calculated as,

$$e_1 = \beta_1 + \beta_{11} ln\bar{x}_1 + \beta_{12}\bar{x}_2 + \beta_{13} ln\bar{x}_3$$

The elasticity of output with respect to inputs measures responsiveness of output to 1% change input. Returns to scale represent percentage change in output due to proportional change for all inputs, estimate as sum of elasticity of all inputs. The estimate greater, equal or less than one implies increasing, equal or decreasing returns to scale.

Variables and their expected Signs

These are presented in Table 1.

RESULTS AND DISCUSSION

Summary of major inputs

Table 2 shows that the mean of labor productivity per day was 0.21, with the standard deviation of 0.31. Also, the mean value of area per labor distribution per day was about 0.02 (±0.02), which implies that there is scarcity of land to labor distribution. The mean value of household's usage of chemical fertilizer is 1.8 (±10.4), the min. and max being 0 and 150, respectively. Table 2 also shows that of all households about 5, 39, and 38% use improve seed, extension service, and credit, respectively. As for the educational level of household head, 65% are illiterate. Moreover, looking at the proportion of agro-ecology zone of the country in terms of teff production, 69% of Teff is produced in Woyena Dega followed by Kolla (21%) and Dega (5%) in 2013/14.

Hypothesis testing

Table 3 shows that the hypothesis of Cobb-Douglas production function is adequate representation and therefore the null hypothesis is statistically rejected at 1% significance level. This implies that at least one intersection of variable is statistically different from zero. Thus, trans-log production function is appropriate for this data presentation. The second test, "inefficiency term not stochastic" is also rejected, because the estimated statistics value is 34 with p value =0.000. There is technical inefficiency in the model; therefore, stochastic production function is appropriate and traditional function (OLS) is not adequate presentation. The last test also shows joint effects of inefficiency model variables statistically significant.

Maximum likelihood estimates (MLE) of Frontier parameters

Table 4 shows the MLE of parameters of trans-log

Table 2. Summary of major input and factor that influence production in survey period of sample household.

Variable	Obs.	Mean	S dev.	Min.	Max.
Labor productivity (output/labor) per day	895	0.21	0.31	0	3.87
Area per unit of labor/hectare	893	0.02	0.02	0.001	0.18
Area per fragmented land (hectare)	895	0.04	0.47	0	0.74
Area per family size (hectare)	886	0.08	0.10	0.001	1.2
Fertilizer in kilogram per household	895	1.8	10.4	0	150
Dap	895	0.77	4.7	0	75
Urea	895	1.04	6.4	0	100
Fragmented land (number)	895	13.7	6.5	2	46
Household size (number)	895	6.5	3.4	1	16
Education level	895	1	0.58	1	4
			Proportion (%)		
Improved seed (yes=1)	895		5		
Extension (yes=1)	895		39		
Other income (yes=1)	895		18		
Got Credit (yes=1)	895		38		

Own Computation, 2016.

Table 3. LR test of hypothesis parameters of SFA production function and technical inefficiency factors.

Hypothesis	LR test statistic	p-value	Decision
HO β_{ij}=0, production function Cobb-Douglas	167.37	0.000	Reject HO
HO $\gamma = 0$inefficiency is not stochasticvs.$\gamma > 0$	34.05	0.000	Reject HO
HOδ_0=δ_1=δ_3=δ_4=δ_5= … … . δ_{10}=0, effect of inefficiency variable zero	61.65	0.000	Reject HO

Own Computation, 2016.

production functions with truncated normal distribution and related statistical tests obtained from stochastic frontier production function analysis. The estimated coefficients of production function show positive signs for area, fertilizer and family size. It implies that they positively contribute to Teff production. On the other hand, fragmentations of land have a negative significant effect on Teff productivity and output also shown by reducing the amount of area, labour, and fragmentation of land has positive strong significant effect on production efficiency. The impacts of intersection of two variables or complement increase both input variables on production. The variables joint effect of increasing inputs is important in areas like fertilizer (5%), labour fertilizer and family size fertilizer (10%), but other area like labour (5%), fertilizer fragmentation of land and others (10%) have significant negative impact, so it is better to decide the amount of usage independently. It means that it is not important to increase those input that may yield negative impact, rather use the opposite amount; if we want to increase the amount of fertilizer we must decrease fragmentation of land; otherwise increased amount of fertilizer may not give expected yield if there is parallel increase in fragmentation of land and so on.

The estimated sigma-square in the study shows 0.55 and also the discrepancy ratio gamma(γ), is different from zero at 1% significance; it indicates one-side error term, dominates the symmetry error term and also shows the appropriateness of model and correctness of distributional assumption; if the mean value is different from zero that distribution assumption is better truncated than half normal distribution for one-side error term that captures inefficiency effect related to specific farm characteristics (Coelli et al., 2005).

The discrepancy ratio(γ) associated with variances explains that total variation from the frontier attributed to technical inefficiency is about 0.85, close to one, suggesting that technical inefficiency effect makes significant contribution to level and variation of Teff production in Ethiopia. Therefore, the shortfall of observed Teff production output from the frontier in Ethiopia is largely due to inefficiency of farmers (lack of efficient farmers that use input efficiently) than random shock. Table 5 shows that in the output elasticity of inputs, fertilizer has the highest elasticity of 0.28 followed by labour with elasticity of 0.18 and area with 0.11; total

Table 4. Maximum Likelihood Estimation of stochastic trans-log production Function of Frontier 4.1 software output.

Variable		Parameter	Coefficient	t-ratio
Constant		β_0	2.6254	14.5035***
AREA	lnx_1	β_1	0.1456	2.1222**
AMLABOUR	lnx_2	β_2	-0.4504	-0.8486
QCFERT	lnx_3	β_3	0.1169	2.13312**
AMFLD	lnx_4	β_4	-0.07218	8.5423***
FSIZE	lnx_5	β_5	0.0860	-1.3526
1/2AREAsq	1/2lnx_{11}^2	β_{11}	0.0748	3.6123***
1/2LABORsq	1/2lnx_{22}^2	β_{22}	0.0430	2.3167**
1/2FRTsq	1/2lnx_{33}^2	β_{33}	-0.0086	0.1638
1/2AMFLDsq	1/2lnx_{44}^2	β_{44}	0.1532	4.2536***
1/2FSIZsq	1/2lnx_{55}^2	β_{55}	0.0305	0.6367
REALAB	ln$x_1 lnx_2$	β_{12}	-0.0453	-2.8341**
AREAFERT	ln$x_1 lnx_3$	β_{13}	0.0293	-1.968**
AREAFLD	ln$x_1 lnx_4$	β_{14}	0.0346	1.3037
AREAFSIZ	ln$x_1 lnx_5$	β_{15}	-0.0024	-0.0759
LABFRT	ln$x_2 lnx_3$	β_{23}	0.0470	1.6910*
LABFLD	ln$x_2 lnx_4$	β_{24}	0.0022	0.0980
LABFSZ	ln$x_2 lnx_5$	β_{25}	-0.0211	-8.328
FRTFLD	ln$x_3 lnx_4$	β_{34}	-0.1174	-1.9573*
FRTFSZ	ln$x_3 lnx_5$	β_{35}	0.0071	0.1177*
FLDFSZ	ln$x_4 lnx_5$	β_{45}	-0.0527	-1.4421
Diagnostic Statistics values				
Sigma square ($\sigma^2 = \sigma_u^2 + \sigma_v^2$)		0.5452	0.7193***	
Gamma($\gamma = \sigma_u^2/\sigma^2$)		0.8513	0.1584***	
Mu(μ)		-1.94	-0.3372**	
Mean efficiency		0.7312		
Sample size		895		

Own Computation, 2016.
***, **, * Shows the Significance level of the estimated parameters of variables at 1, 5 and 10% respectively.

Table 5. Output elasticity of input.

Variable	Elasticity
Area	0.11
Labour	0.18
fertilizer	0.28
Total	0.57

Own Computation, 2016.

elasticity of output based on all inputs is 0.57 which is less than one if other constant 1% increase of these inputs leads to output increase by about 0.57%. Thus average production of Teff decreases returns to scale. Similarly in pervious study, Susan et al. (2014) got positive elasticity of farm size, labour and fertilizer with high coefficient of fertilizer on maize in Zambia.

Determinants of technical efficiency

The analysis of estimated coefficient of inefficiency model tells us the contribution of variable to technical efficiency in the country. Source of inefficiency was observed using the estimated coefficient associated with inefficiency effect. Table 6 shows the coefficients of the parameters of agro-ecological zones, age, extension, sex of household, seed type and other income. Having a negative coefficient implies that the variable has positive impact on efficiency which helps to decrease inefficiency or increase efficiency of Teff production. The variable “SEEDTYPE” is statistically significant at 1%; while the variable Dega, age, extension and other income has significant effect of 5% level to reduce inefficiency and increase efficiency of production. Also there is unexpected sign that education is positive, meaning it has negative impact on efficiency of Teff producers that increase inefficiency. The reason behind this may be due

Table 6. Determinant /Factors/ of technical efficiency in inefficiency model.

Variable	Parameter	coefficient	t-ratio
Constant	δ_0	1.6819	3.8702***
KOLLA	δ_1	-0.0943	-0.0541
DEGA	δ_2	-4.8350	-2.5767**
WDEGA	δ_3	-0.2210	-1.9098*
AGEH	δ_4	-0.2306	2.3184**
EXTENSION	δ_5	-0.1080	-1.7031**
SEXH	δ_6	-0.1246	-1.0042
SEEDTYPE	δ_7	-0.6954	-3.7840***
EDUCATION	δ_8	0.0797	1.1951
OTHERINC	δ_9	-0.2273	-2.1221**
CREDIT	δ_{10}	0.1486	0.2483

Own Computation, 2016.

Table 7. Yield gap due to technical inefficiency.

Variable	Mean	Std. dev	Min.	Max.
Actual yield (quintal/hectare)	13.49	6.90	1.10	39.29
Mean TE	0.73	0.1572	0.1344	0.9278
Potential Yield (quintal/hectare)	19.56	6.30	8.05	47.00
Yield gap (quintal/hectare)	6.09	1.32	3.41	12.02

Own Computation, 2016.

to other factors that contribute to inefficiency like if they are educated few time would be allocated for farm work and they may do other jobs besides agricultural production, thus not working properly on field. Their contribution to production would be low. This would reduce household resources not properly utilized for crop production leading to negative impact. Therefore, the socio economic factors which influence technical efficiency of Teff production have negative coefficients; agro-ecology, age, extension, seed type and other income are important factors that increase efficiency; they have positive contribution, specifically Dega has high contribution with largest coefficient of 4.84 followed by seed type, 0.69, age 0.23 and Woyena Dega, 0.22; others also have significant contribution to increasing the efficiency of Teff producers. Similarly, Bamlak et al. (2014) found age, extension, seed type and income have significant effect on technical efficiency of maize production. The yield gap is difference between technically full efficient /possible maximum/ output and observed output/Yield/. Hence gap loss of yield due to inefficiency is:

$TE = \exp(-u)$, and $Y^* = \frac{Y}{TEi}$,

based on formula potential Teff output of each household estimated and mean result presented in Table 7. From the table it can be observed that mean technical efficiency was 73%; it implies mean technical inefficiency (27%) caused mean yield gap of 6.09 quintal/hectare for actual 13.49 and potential 19.56 quintal/hectare yield production of Teff. As a result, farmers produce on average 6.09 quintal per hectare lower Teff output than their potential yield can produce. The distribution of technical efficiency estimates are obtained from stochastic frontier model. Table 8 presents the summary statistics of TE scores at which farm operates and it shows that efficiency level from 13% to 92% with mean efficiency of 73% indicates that producers obtain over 73% potential output from given mix of production inputs. There is probability of increasing efficiency that farm can increase their efficiency by 27% using the same amount of resource and at a given technology. They can even increase above 27% if they adopt improved technology.

The distribution of technical efficiency among the sample of 895 households Teff producers increases with proportion of number of households, then it starts to decline when household proportion is above 80%. It also describes those 5 farmers below 30 and 5.4% were below 50%. Generally, there is high efficiency variation between lowest to highest relative efficient household; household about 72% is above mean efficiency level; as a result, most households are above mean efficiency,

Table 8. Distribution of farm specific Technical efficiency score.

Efficiency	Frequency	Percentage	Cumulative p.
<30	5	0.6	0.6
30-39.99	18	2	2.6
40-49.99	25	2.8	5.4
50-59.99	74	8.3	13.6
60-69.99	135	15.1	28.7
70-79.99	347	38.8	67.5
80-89.99	289	32.3	99.8
>90	2	0.2	100
Total	895	100	

Own Computation, 2016. The distribution of technical efficiency.

that is more than 50% of household are producing above average efficiency and below average are less than 30%.

CONCLUSION AND POLICY IMPLICATION

The study estimates technical efficiency and also socio economic and farm specific factors that influence technical efficiency in Teff production among smallholder farmers in Ethiopia. The data are obtained from a sample of 895 randomly selected rural households of Teff producers in Ethiopian socio -economic survey; they are analyzed using trans-log production function with assumption of truncated disruption of inefficiency error term.

The result shows that Teff producers in Ethiopia are technically inefficient, that is their mean efficiency calculated is about 73% and distribution of technical efficiency ranges from 13 to 92% with about 5.4% of household below 50% and about 72% household above mean efficiency. This shows there is high variation of technical efficiency between smallholder Teff producers in the country. Even if most households produce above mean efficiency level there is also possibility of increasing efficiency by about 27%.

MLEs area, labour, fertilizer and fragmentation land make significant contribution to enhancing productivity of Teff, and also other determinants of socio economic factors like seed type, AEZs, extension, and other income significantly determine productivity level. Therefore, sound government intervention is pivotal in enhancing smallholders' productive efficiency.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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