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Gender Differentials in Scale and Technical Efficiencies among Improved Wheat Variety Growers in Wheat Belt Areas of Ethiopia: A Data Envelopment Analysis (DEA)

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Abstract
The study employs the Data Envelopment Analysis (DEA) to evaluate the scale and technical efficiencies by gender. Primary data were obtained through the use of a set of questionnaire from two hundred eighty seven representative sample wheat plots of men and women wheat farmers from three districts of Arsi zone, Ethiopia. The results show that women farmers are more technical efficient than men farmers with mean technical efficiency indices of 0.808 and 0.700, and scale efficiency indices of 0.780 and 0.816, respectively. The second stage regression forfemale farmers indicates that fragmentation, farm size, location, technology adoption, fertility status, tenancy, extension access and credit access were found to be important determinants of technical efficiency. While for the male headed households the regression shows that positive and significant correlation between adoption of wheat technologies and efficiency. Policies should therefore target improving female wheat farmers' access to wheat technologies, fertilizer, and extension and credit services. Due to labor and time constraints women faced, technologies generation should also be gender sensitive. In the case of male farmers future agriculture policies should focus on measures to improve the capacity of male farmers to apply the available technology more efficiently. This can be done by improving access to extension services and wheat technologies for male farmers.
Keywords: Gender differentials, Data Envelopment Analysis, Scale and Technical Efficiency, Rust resistant Wheat varieties

1. Introduction

In Ethiopia wheat crop production is mostly practiced by subsistence smallholder farmers and characterized by low productivity. According to survey report of Central Statistical Authority (CSA) (CSA 2012 / 2013), the average national productivity of wheat is 21.1quintals per hectare which is too low compared to the Eastern Africa and Africa average wheat productivity. However, the current wheat productivity is high in some model farmers 4 to 6 tons per hectare is evident to see that there is great potential for wheat productivity improvement in some deviations in wheat productivity among farmers. As a result, the country has become increasingly dependent on food import in recent years to feed the populations.

In a bid to maintain productivity growth and curb the threat from the climate change and variability on wheat production, the Ethiopian Institute of Agricultural Research (EIAR)with Regional Research Institutes have developed high yielding wheat varieties for different seasons and agro-ecological zones through their different research centers. However; the transfer and adoption of agricultural technologies is affected by who owns productive resources and who decides what to produce, when to produce, and how much to produce. A study by (Adiss, et al. 2001) in the country showed that the Male and Female headed households had differences in endowments (land rights, education) and differential access to technologies, factors of production, and support services. These differences in turn had implications for the productivity levels and adoption capacities of both types of households.

Gender differentials in relation to farm productivity in subsistence farming has been of special interest from the standpoint of public policy in developing countries, as the difference is often viewed from the angle of human capital theory and measurement of discrimination. The role of rural women in agricultural development draws not only the attention to the academicians but also to the politicians, assuming that gender equality does matter for overall economic development and welfare measurement. On academic arena, gender differences are often discussed with non-homogenous characters and genderspecific constraints that might vary in the productivity of men and women (Thapa 2008). In this regard, (Urdy C. 1996) shows that yield differences between male and female are due to gender-specific constraints such as land, labour, access to inputs (i.e. fertilizer, modern variety of seeds, oxen and other farm equipment) and credit faced by female managed farms in comparison to male managed farms Africa.

In Ethiopia, a study by (Adiss, et al. 2001) using gross value of output per hectare as a proxy of productivity estimates indicated gender differences in productivity due to gender-specific constraints such as farmer's age, family labor, farm size, livestock units, inorganic fertilizer, hired labor, and extension contact. According to the study by (G.H. , Yeshi and G.J. 2003) they show that production efficiency difference using yield per hectare for male and female respondents.

In wheat predominant areas of Ethiopia men are considered to be the head of household regardless of their role in wheat farm investment decisions. It is also true that men are the main decision maker for investment. On the other hand, women are normally supposed to be a household head only in the absence of their male counterparts, either due to the death of their husband or seasonal migration for wage work. The finding of Regassa A (2002) asserts agricultural activities are predominantly men's task among the Oromo, South East-Shoa administrative zone of Ormiya region. In this zone, women's involvement in agricultural production, like the household to the other. Ploughing is entirely men's activity.

Following the above evidences, we employed the unitary model for the measurement of gender differentials in farm productivity in order to acquire data related to plot level managed by both men and women separately.
In Ethiopia, different studies have been conducted to assess the gender differential performance of the agriculture production For instance, in order to measure productivity difference (Adiss, et al. 2001) used Cobb-Douglas production function. While (G.H. , Yeshi and G.J. 2003) used yield per hectare. However to the best of the authors' knowledge, no study to date estimated either technical or scale efficiency; and used DEA in order to measure technical and scale efficiencies as a measure productivity differences for male and female managed plots in the country.

Henceforth, in this study we attempt to calculate different measures, technical and scale efficiency for male and female managed wheat plots. Henceforth; the study provides useful information for policy implication for gender analysis by estimating technical and scale efficiency.

The objective of this paper is to estimate the technical and scale efficiencies for male and female managed wheat plots of smallholder's wheat farmers in the study area and to provide empirical evidence on factors influencing the over- all technical efficiencyfor male and female managed wheat plots. The rest of the paper is organized in three sections. Section II focuses on Research methodology. The third section discusses the results of the descriptive statistics, DEA efficiency estimates and the tobit regression models for female and male headed households. The last section summarizes the main findings of the study and draws appropriate conclusions.

2. Research Methodology

The study was conducted in three districts of Arsi zone namely Arsi-robe, Digelu-tijo and Hetosa districts, Ethiopia. A household questionnaire was used to collect primary data from wheat farmers in the study area, from May 22 to June 08, 2013.Two sampling frames one for female headed household and the other for male headed households were obtained from the respective districts' agricultural offices. Probability proportional to sample size technique was then performed to ultimately select a sample of 177 farmers. Properly trained and carefully selected enumerators pre-tested the questionnaire and later collected data on input use, outputs and socioeconomic and farm characteristics.

The total sample size (177) which consisted of 120 male-headed and 55 female-headed households and interviews were conducted by means of structured and semi-structured interview schedules.

2.1 Sampling procedures

A multi-stage purposive and simple random sampling method was used. The first stage involved a purposive selection of three districts that are representative of wheat based farming systemsmen and women who are actively involved in wheat production. Next a total of six villages[1] were considered for the study, namely Habe-guche, Fite-ketar, Kechema-murkicha, Sheki-sherera, Asindabo and Sude-waliti.At final stage, simple random sampling techniques were employed for selecting 55 female and 122 male headed households who are wheat farmers from each of the six villages making a total of 177 wheat farmers.

[1]The lowest administration unit in Ethiopia.

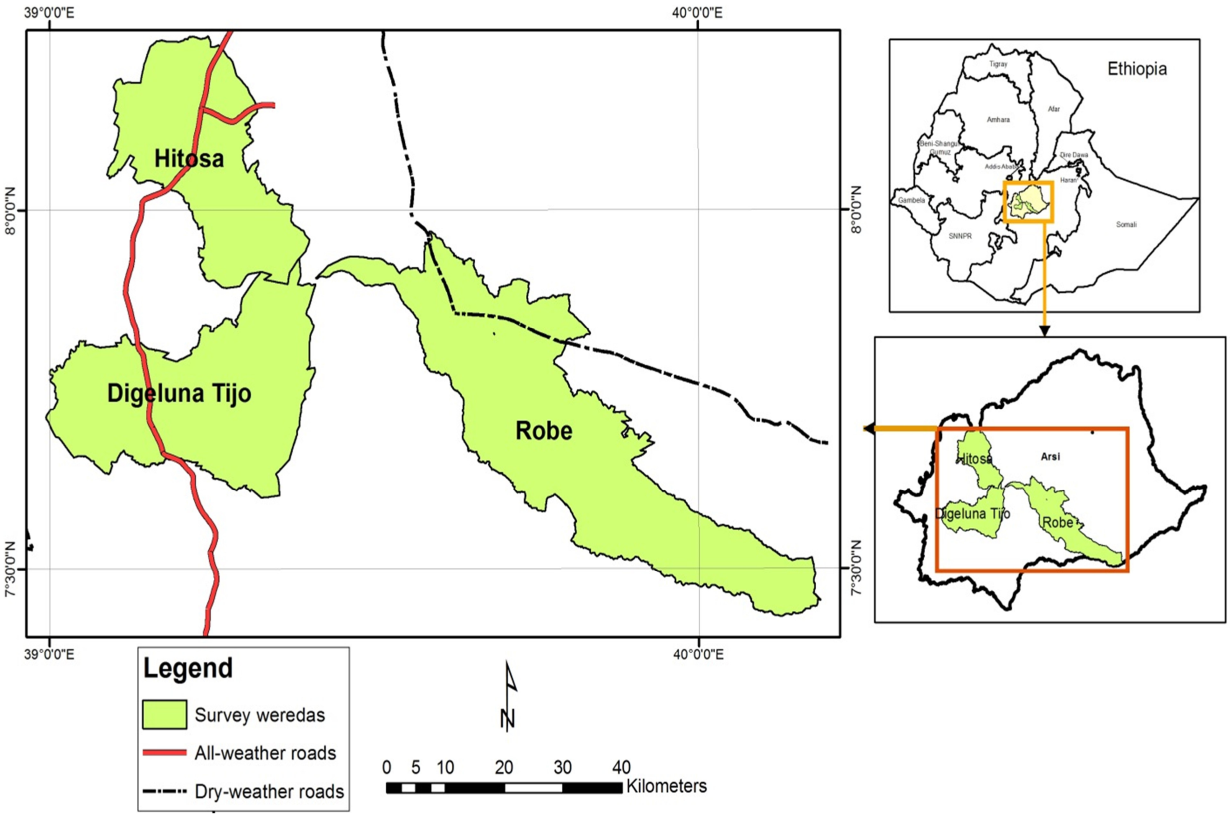

Figure 3: Map of the survey districts

2.2 Method of Data Analysis

Descriptive Statistics was used to analyze the socio economic characteristics and institutional variables while the non-parametric approach of the data envelopment analysis (DEA) employed to estimate the scale and technical efficiency indices. Ultimately, Tobit model was employed to identify the determinants of technical efficiency for female and male headed households.

2.3 The data envelopment analysis (DEA)

Based on earlier work by (Debreu 1951), (Koopmans 1951)and (Farrell 1957), DEA was introduced by (Charnes , Cooper and Rhodes 1978). It involves using linear programming to estimate a non-parametric production frontier based on data for a group of decision-making units (DMUs) wheat farmers in our case. However, this earlier work considered overall technical efficiency (technical efficiency at constant returns to scale). Subsequent modifications to those indices allowed the presence of non-constant returns (also called variable returns to scale) that decompose the overall technical efficiency into a scale efficiency index and another which is a measure of the technical efficiency excluding the effect of scale (Banker, Charness and Cooper 1984).

One thus obtains an index of pure technical efficiency which refers to the degree of efficiency when the existence of variable returns to scale is allowed, and which therefore does not include the portion of any inefficiency that is the result of not operating at the optimal scale. The other component of the overall technical efficiency, the scale efficiency (SE), can be interpreted as the additional reduction that could be attained in the consumption of inputs if the technology were to present constant returns to scale at the point corresponding to the production unit (Gaspar , et al. 2009).

Both input-based and output-based efficiency measures have been used. Although the two approaches are equivalent under constant return to scale, they differ under variable return to scale (Fare , Grosskopf and Lovell 1985). In this research, an input orientation has been used given the argument that farmers are able to control their inputs more easily than outputs.Henceforth, in this study in order to obtain pure technical and scale efficiency indices, an input orientated technical efficiency measures satisfying three different types of scale behavior are specified. These areconstant returns to scale, (CRS), variable returns to scale (VRS), and non-increasing returns to scale (NRS).

The DEA input oriented model assuming (CRS) used for calculation of technical efficiency(Charnes , Cooper and Rhodes 1978)is:

$$\mathrm{Min}_{\theta,\lambda}\,\theta \qquad (1)$$

$$\text{subject to: } Y\lambda - yi \geq 0$$
$$\theta\, xi - X\lambda \geq 0$$
$$\lambda \geq 0$$

Where we assume that we have K inputs, M outputs, N farms and that x_i and y_i are the inputs and outputs for the i-th farm. X is K by N input matrix, Y is an M by N output matrix, θ is a scalar and l is a N * 1 vector of constants.

The value of θ estimatedwill be the efficiency score of the i^{th} farm. It will satisfy the conditionθ≤1, with a value of 1 indicating a point on the productionfrontier and thus a TE farm. A value less than one indicates the farm, given the set of observations in the sample, can improve the efficiency of its inputs byforming benchmarking partnerships and emulating the best practices of its reference or peer group of farms. Note that the linear programming problem must be solved N times, to obtain a value of θ for each farm in the sample.

The CRS specification assumes that all wheat farmers are operating at optimal scale. However, scale inefficiency may arise from a number of factors. To measure in efficiencies due to scale, and to identify the optimal scale for a farmer, two more DEA models need to be solved. These are the VRS and NRS model specifications.

Estimating a VRS specification allows TE to be estimated without the influence of SE. To estimate the VRS specification, an additional convexity constraint,N1’ , is added to the programming problem (1) above, and N1 is an N by 1 vector of ones. The VRS specification forms a production frontier that envelopes data more closely than the CRS specification. Therefore, the resulting efficiency scores are equal to or greater than those obtained with the CRS model. The additional convexity constraint ensures that an inefficient farmer is only being compared against farmers of similar size. Thus, by estimating both CRS and VRS specifications, TE estimates can be decomposed into two components, PTE and SE. If there is a difference between the CRS and VRS TE scores, this indicates scale inefficienciesexist.

Assuming a wheat farmer is scale inefficient, in order to assess if it is exhibiting increasing or decreasing returns to scale (IRS/DRS), a non-increasing returns to scale (NIRS) specification is required to be estimated. The NIRS specification adjusts the restriction N1′λ=1, such that N1′λ=1. This constraint ensures that farmer’s will only be compared to farmers of the same or smaller size, not with any farmer’sthat is larger. To determine if IRS and DRS exists, the NIRS TE is compared to the VRS TE estimate. If the two are unequal, then this indicates IRS and the scale of farm level operations can be increased. If the two are equal, DRS exist and farm operations needs to be reduced in size (Graham, Iain and Mary 2005).

2.4 Second-Step Analysis of TE Scores: Tobit Regression model

As a part of two-stage DEA approach, we carried out a regression analysis to estimate the effect of a set of variables on the technical efficiency of wheat farmers. In DEA literature, the influence of these variables is usually analyzed by applying either tobit or logistic regression models because the distribution of efficiency scores is confined to the interval (0, 1]. In the presence of censored range of efficiency scores obtained through DEA, the OLS regression method yields inconsistent estimates of regression parameters. To account for this caveat, we employed tobit regression analysis to explore the factors causing differences among wheat farmers in overall technical efficiency. The same logic was followed on different efficiency studies (See (Coelli, Rahman and Colin 2002))who used tobit regression model to identify determinants of efficiency, we applied tobit regression analysis in the present context to explore the factors causing differences among wheat farmers in overall technical efficiency.

The tobit (Tobin 1958) model specification is defined as

$$y_i = y_i^* \quad \text{if} \quad y_i^* > 0 \qquad (1)$$

$y_i = 0$ Otherwise

The latent function y_i^* that defines wheat farmers’ household head over all technical efficiency is given by:

$y_i^* = x_i'\beta + \varepsilon_i$, where $\varepsilon_i \sim N(\mu i, \sigma^2)$ and i = 1,…, n

$x_i$is a set of individual characteristics that determine the technical efficiency of wheat farmers, and β is vector of Tobit maximum likelihood estimates, μ^i the independently and normally distributed error term assumed to be normal with mean zero and constant variance σ.

2.5 Input and Output Variables for Computing Efficiency Scores

In computing the efficiency scores, the most challenging task that an analyst always encounters is to include exhaustively all the relevant inputs and outputs for modeling farmers production behavior. Obviously, frontier functions assume that all inputs have been taken into consideration. However, in this study we used the input variables land planted to wheat, family and hired labor cost, fertilizer in kilogram, seed cost, chemical costs and draft animals. And the output variable as quintals (100 kilograms) of wheat harvested.

2.6 Variables explaining the technical efficiency

The study used variables x_i made up of producers' age, fragmentation, level of education, experience in wheat production, family size, working adult, wheat farm, model (best farmers) rented in land, location, improved wheat variety adoption, farmers perception of fertility status of wheat farm, asset ownership, livestock ownership, market distance, credit access, and extension access .

3. Results and Discussion

3.1 Descriptive statistics

Table 1 presents the summary statisticsof some important socio economic variables for wheat farmers in the study area. The result of table 1 shows that women farmers own relatively smaller land (mean land size of 2.03 ha) compared to their men counterpart (mean land size of2.57 ha) and is significantly different at 5 percent level. On average, men farmers had larger households (mean=7.24) than women farmers(mean=6.00) in the study area. The average family size was significantly higher in male headed than female headed households at 1 percent significant level. In terms of livestock ownership in birr as a proxy measure of asset ownership, male farmers on average had more livestock ownership than female farmers. The mean livestock ownership for male and female farmers were birr 42,665.16 and 28,012.73, respectively, which was significantly different at 1percent level. Table 1 also shows as there is significant difference of farm income between male and female farmers. Male farmers had more farm income than female farmers. In general the finding empirically vindicates our prior hypothesis that there are gender gaps in land ownership, family size, asset ownership and farm income in agricultural production.

Table 1: Socioeconomics variables

Variables	Statistics	Male headed N=120	Female headed N=55	t-test
Age of the household head	Mean	43.13	43.33	
	Std. Deviation	12.03	11.01	(0.11)
Education of household head	Mean	25.69	24.95	0.40
	Std. Deviation	11.85	10.43	
Land owned	Mean	2.57	2.03	2.52**
	Std. Deviation	1.94	0.86	
Family size	Mean	7.24	6.00	3.147***
	Std. Deviation	2.45	2.22	
Livestock ownership	Mean	42,665.16	28,012.73	3.66***
	Std. Deviation	30,456.55	21,664.93	
Farm income	Mean	40,767.20	17,525.31	4.694***
	Std. Deviation	50,342.48	14,338.68	
Non-farm income	Mean	3,781.19	4,333.09	(0.39)
	Std. Deviation	8,978.13	8,070.52	

Source: Authors' computation from the survey 2013

3.1.1 Adoption of major crop technologies in the study area

In the study area the major crops cultivation are wheat, barley and teff. According to table 2, in Digelu, about 51.7% of Male headed and 35.3% of Female headed households adopt improved wheat varieties. In Arsi robe, 64.9% of Male headed and 61.5% of Female headed households adopt improved wheat varieties. In Hetosa, 58.3% of Male headed and 8.3% of Female headed households adopt improved wheat varieties. The use of wheat varieties showed more male headed households grew improved wheat varieties than female headed household varieties.Table 2 showed that very few farmers adopt improved varieties of teff, food barley, and malt barley.

Table 2: Use of local and improved major crop varieties in the study area

Crop type/variety		Districts											
		Digelu				Arsi Robe				Hetosa			
		MHH		FHH		MHH		FHH		MHH		FHH	
		N	%	N	%	N	%	N	%	N	%	N	%
Wheat	Local	22	75.9	10	58.8	22	38.6	13	50.0	27	75.0	12	100.0
	improved	15	51.7	6	35.3	37	64.9	16	61.5	21	58.3	1	8.3
Teff	Local	3	10.3	-	-	42	73.7	17	65.4	3	8.3	1	8.3
	improved	1	3.4	-	-	5	8.8	3	11.5	-	-	-	-
Food barley	Local	15	51.7	3	17.6	13	22.8	7	26.9	16	44.4	8	66.7
	improved	2	6.9	1	5.9	3	5.3	-	-	1	2.8	-	-
Malt barley	Local	-	-	-	-	1	1.8	-	-	-	-	-	-
	Improved	1	3.4	-	-	-	-	-	-	1	2.8	-	-

3.1.2 Credits Access

During 2012/13 crop production season, 41 percent of the MHHhad borrowed credit for agricultural inputs while over 53 percent of FHH had borrowed credit for agricultural input. This shows that FHH has financial constraints, in order to relax their financial limitations they borrow.

Table 3: Credits borrowed during 2012/13 crop production for agricultural inputs

Access to creditduring 2012/13 crop production for agricultural inputs		Male headed		Female headed	
		N	%	N	%
Credit borrowed	Yes	43	41.0	28	53.8
	No	62	59.0	24	46.2

Source: Authors' computation from the survey 2013

3.1.3 Access to extension contact

Table 4 showed the frequency of extension contacts made by extension agents for wheat production during 2012/13 cropping season in the study area. According the result, on average male headed households were contacted 4.57 times while for female headed household it was 3.67 times. However, there was no significant difference between male and female headed households. The result implies the number of contacts by extension agents for both group of farmers were the same.

Table 4: Number of extension contacts during 2012/13 cropping season for wheat production

Number of extension contact	Statistics	Male headed	Female headed	t-test
Extension contact	Mean	4.57	3.67	1.378
	Std. Deviation	3.33	2.94	

Source: Authors' computation from the survey 2013

3.1.4 Productivity differences

Comparisons between the wheat productivity of male and female respondents revealed significant wheat yield differences. The average yield for the male respondents was 2079.67 kg/ha and1340.3 kg/ha for the female respondents, which amounts to a very significant statistical difference ($t = 4.020$, $P = 0.000$).The plausible explanation for the differences in yield between male-and female-headed households is the differences in access to and the adoption of improved wheat varieties.

3.2 Econometric results

3.2.1 Pure technical and scale efficiency

The results of the DEA methods are reported in Table 5. Summary statistics for the measures of technical, and scale efficiencies are listed in Table 5. The average technical efficiency score is 0.808 for FHH and 0.700forMHH. This suggests that the average farm is producing 80 percent of the potential output level for FHH and 70 percent for male headed. Thus, in the short run, there is a scope for increasing wheat production by about 19.2 percent for women farmers and 30 percent for men farmers if the inefficient categories of farmers adopt the technology and techniques used by the most efficient farmers amongst them. In Nigeria, (Adeoti , Timothy and A. 2006) have also revealed that female farmers are more efficient than male farmers in cassava production. Similarly, a study by (Fajuyigbe, Oladeebo and A. 2007) shows that women farmers are more technically efficient than male farmers with mean technical efficient indices of 0.904 and 0.897, respectively.

Moreover, Table 5 illustrates the scale efficiency of female and male headed household wheat producers, respectively. It is evident that both female and male headed household wheat producers are not producing at their optimum scale of operation. Considering their estimated scale efficiencies, male headed households seem to be slightly more scale efficient than the female counterparts, with a 0.816and 0.780 level of scale efficiency, respectively. These figures indicate that farm size issue is much more important relative to the amount of technical efficiency for female wheat farmers while technical efficiency for male wheat farmers. Lastly, Table 5 lists the percentages of farms which have increasing returns to scale (IRS), constant returns to scale (CRS) and decreasing returns to scale (DRS). Between the two household head wheat producers, the results are largely skewed to IRS for FHH than the male counterparts. This further confirms the result of the descriptive statistics of the smaller farm size of female farmers. This implies as there is an opportunity for female farmers to reap the scale of economies by increasing their scale of operation than the counterpart male farmers in wheat production.

Table 5: Technical and Scale efficiency estimates

Statistics	Female headed households		Male headed households	
	TECHNICAL	SCALE	TECHNICAL	SCALE
Mean	0.808	0.780	0.700	0.816
Standard Deviation	0.224	0.217	0.240	0.200
Minimum	0.274	0.284	0.096	0.111
Maximum	1	1	1	1
Count	67	67	220	220
<60%	25.4%	23.9%	40.9%	17.7%
60 – 69%	4.5%	11.9%	10.9%	4.1%
70 – 79%	11.9%	10.4%	10.0%	11.4%
80 – 89%	3.0%	14.9%	8.2%	20.9%
90 – 99%	14.9%	19.4%	3.6%	33.6%
100%	40.3%	19.4%	26.4%	12.3%
IRS (%)		76		61
DRS(%)		4		19
CRS (%)		19		12

Source: Authors' computation from the survey 2013

3.2.2 Determinants of technical efficiency analysis

In order to identify the determinants of technical efficiency, the efficiency score estimated by the DEAmethod was regressed on household socioeconomics, farm level characteristics and institutional variables using the Tobitmodel. Before employing the Tobit regression model, a likelihood ratio (LR) test was conducted in order to empirically show that whether the independent variables have statistically equivalent effect on the dependent variables for both female and male headed households. According to the result of Table 6, the LR test rejects the null hypothesis of the pooled model at 5% significance level and implying the set of coefficients for female and male headed households are different. This could be due to the different socio-economic and other situations facing both female and male headed farmers in the wheat production.

Table 6: LR test

	Male headed	**Female headed**	**Pooled**
Log likelihood	16.648752	21.104384	11.890419
Chi-square	32.6921	[Pooled – (Male headed + Female headed)]	
Degree of freedom	20		
Critical value	31.4	P= 0.05	

Source: Authors' computation

3.2.3 Factors affecting the technical efficiency for female headed households

Table 7 shows the determinants of technical efficiency forFHH. According the result of table 7, market distance, fragmentation, farm size, location, technology adoption, fertility status, tenancy, extension access and credit access found to be significant factors affecting technical efficiency of female headed households.

Even though market distance, asset and livestock ownerships are found significant, their effects on technical efficiency are very small. The coefficient of fragmentation variable is estimated to be negative as expected and statistically significant at 5 percent level for female farmers which indicates that female farmers with smaller number of wheat plots tend to be more efficient technically. This is probably due to time and labor constraints, female farmers manage a smaller number of plots. Besides, this finding confirms fragmented land reduces efficiency index.

On the other hands, coefficient of farm size showed positive value for female headed household. The positive significant ($P < 0.05$) coefficient value for wheat farm size suggested that expanding the wheat growing area for female farmers increases their efficiencies. The result is consistent with scale efficiency score previously presented in this paper for female farmers.

Turning to the effect of female farmers access to credit, the finding showed that a positively significant effect on efficiency. The plausible explanation for is that farmers'accessto credit enhances their timely acquisition of production inputs that would enhance productivity via efficiency.

In contrast to our priori expectation the coefficient of extension contact is found negative and significant at (<0.05) level. The negative impact of extension contact on female wheat farmers' efficiency is a surprise. The result shows that extension activities have been biased towards male wheat farmers in the study area. In terms of location, the study reveals that female farmers who are located near to research center and main road found to be more efficient. This is probably due to access to technologies and easy flow of wheat associated information.

With regard to perception of farmers' soil fertility status, the impact of soil fertility perception on wheat efficiency is found to be negatively significant at 5 percent level. This result is inconsistent with our priori expectation. The probable explanation is that much of the efficiency differences across the sample female wheat farms can be attributed to management issues (for instance, application of fertilizer) rather than physical differences.

The result of the tobit regression model for female headed farmers reveals that the impact of tenancy status on wheat efficiency is significantly positive at 10 percent level. This shows female farmers are acquiring land ownership through land renting as a short run remedy so as to increase their scale of operations ultimately reap the economies of scale. As per our priori expectation, the impact of adoption of wheat technologies on wheat efficiency is found positive and significant at 1 percent level. Thus the result empirically confirms that technology adoption increases production and productivity.

Table 7: Tobit model for female headed households

vrste	Coef.	t
Age	-.0107817	-1.21
Market	.0089499***	4.77
Fragementation	-.162463**	-2.18
family_s	-.0299607	-1.07
Model farmer	.0704162	1.07
Farmsize	.1172341**	2.70
Robe_hetosa	-.337769***	-3.31
Digelu_hetosa	-.1205561	-1.35
Experience	.001888	0.22
Education	.0145634	1.36
Workingadult	-.0408266	-1.16
Adoption	.2557775***	3.65
High_ soil fertility	-.2028193**	-2.31
Medium_soil fertility	-.0686014	-0.91
Rented land	.2467479*	1.77
Extension access	-.2132306**	-2.09
Creditaccess	.1408937*	1.90
livestock	3.75e-06*	1.78
Asset	-1.11e-06**	-2.23
Cons	1.576555	4.36
/sigma	.1245739	

Source: Authors' computation from the survey 2013

3.2.4 Factors affecting the technical efficiency for male headed households

Table 8 shows the determinants of technical efficiency for male headed households. In the case of male headed households, the results of table 8 show that farming experience, household education status, the number of working adult in the household, livestock and asset ownership and adoption of improved wheat varieties found to be significant factors affecting wheat technical efficiency.

According to the results, farming experience was significant at the anticipated negative sign, while education, and working adult became significant positively, but their effects on wheat efficiency are very small. Similarly, the tobit regression model for male wheat farmers reveals that the variables livestock and asset ownerships are found significant; however, their effects are very small on wheat technical efficiency.

On the other hand, the coefficient of adoption of wheat technologies has the expected positive sign and significant at 10 percent level. This means for male headed wheat farmers only being an adopter of wheat technologies was enough to significantly cause a male farmer to attain higher levels of efficiency.

Table 8: Tobit model for male headed households

Vrste	Coef.	t
Age	.003832	0.81
Market	-.0001786	-0.77
Fragementation	-.0256074	-1.25
Family size	.0164764	1.59
Model farmer	-.0187112	-0.37
Farmsize	-.0103178	-0.69
Robe_hetosa	-.0716302	-1.30
Digelu_hetosa	.0268445	0.48
Experience	-.0089999**	-2.01
Education	.0058109***	3.70
Workingadult	.0425036**	2.40
Adoption	.0797505*	1.71
High_soil fertility	.0314089	0.53
Medium soil fertility	.0504214	0.91
Rented land	-.0081595	-0.12
Extension access	.0064988	0.10
Creditaccess	.0613759	1.43
Livestock	2.58e-06**	2.45
Asset	-4.47e-07***	-2.71
Cons	.3856483	2.51

Source: Authors' computation from the survey 2013

4. CONCLUSIONS

Even though the widely used unit of analysis for gender indicator is intra household level, this study used household head as gender indicators. Because in male headed households for wheat cultivation, most of the time the wheat plot is mainly managed by the male head households. For example, from plowing to threshing the activities dominantly carried out by the male farmers. Female households in the male headed households have limited participation in wheat cultivation especially in the study area.

The study uses the non-parametric approach of the data envelopment analysis to estimate the technical and scale efficiency score for female and male headed households. The results show that a considerable amount of inefficiency (technical and scale) exists in wheat production for female and male farmers in Ethiopia.They are relatively inefficient, with a potential for reducing input or increasing output in the range of just over 19% for female farmers and 30% for male farmers.The obtained measures of efficiency indicate the potential that exists for improving farm income by improving productive efficiency. The estimates also show that female headed households are more technically efficient while male households were more scale efficient. The results imply scale (size) efficiency is important for female headed household compared to male households. For male headed households technical efficiency is more important than the female counter parts. This implies the large gender differences in yield do not mean that women are less efficient farmers than men. The differences in yield might attribute differences in access to inputs, adoption of wheat technologies and in other words to the level of inputs used by male and female farmers.

The analysis of the determinants of technical efficiency for female farmers indicates that fragmentation, farm size, location, technology adoption, fertility status, tenancy, extension access and credit access were found to be important determinants of technical efficiency. Policies should therefore target improving female wheat farmers' access to wheat technologies, fertilizer, and extension and credit services. Due to labor and time constraints women faced, technologies generation should be gender sensitive. This will in turn improve female farmers' productivity and efficiency. Moreover, the findings give conclusive evidence with regard to the degree of relationship between efficiency and farm size for female farmers. It may be worth attempting to improve results by increasing the size of farms in the case of female farmers' wheat production, where we found a positive and significant relationship to exist between the two.

In the case of male wheat farmers, the analysis of the determinants of technical efficiency for male farmers indicates that the positive and significant correlation between wheat technologies and efficiency. However; none of the other factors found important. This suggests that for male wheat farmers technical efficiency appears to be conditional on adoption of wheat technologies with its associated packages. Based on these findings, future agricultural policies need to focus on measures to improve the capacity of male farmers to apply the available technology more efficiently. This can be done by improving access to extension services and wheat technologies for male farmers.

5. References

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