Productivity and Efficiency of Agricultural Extension Package in Ethiopia

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The Ethiopian Development Research Institute (EDRI)

Research Report 5

Addis Ababa, Ethiopia
June, 2006

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1. Background

It is always claimed that Agriculture remained to be the mainstay of Ethiopian economy despite the dismal performance of the sector. Various factors were held responsible for poor performance, despite the attempts were made to modernize it. In an effort to change the living standard of the population and to transform agriculture, the government declared the Agricultural Development Led Industrialization (ADLI) in 1993.In the broader context of ADLI, agriculture is expected to fuel the industrial growth simultaneously. Following ADLI, Rural development policy and strategy has been defined particularly focusing on agricultural development.

One of the major programs in the rural development in general and the Ethiopian agriculture in particular is the extension package that supported the promotion of modern agricultural technologies and intensifies agricultural growth. The major outcome of the the 1991 market liberalization is that Ethiopian peasants can produce and sell their produce at the free market prices. The pre-1991 command economy largely created disincentive to the farmers to market their output and this has remained to have constrained output and further growth in productivity despite the introduction of new technologies in the mid 1970s up until end of 1980s. According to Todaro (2003) the prevalence of technology in agriculture may not attain its target goal unless the social, institutional, cultural and commercial, constraints are improving. Given an irreversible trend of declining size of cultivated land, with the population growth, mismatch with production, one of feasible way to raise production would be to increase land productivity through agricultural extension. Many evidences have indicated that due to land shortage, cropping systems in Africa is in transition from farm abundant to land constrained system (Reardon et al 1996). It is therefore, suggested that for rapid growth in agriculture to be sustainable there is a need for generating and adoption of various alternative technologies.

Since 1995/96-cropping season when Participatory Agricultural Demonstration Extension of Technology (PADETS) became operational, fertilizer and improved seeds have witnessed widespread with increasing rates of adoption, despite the removal of all input subsidy since 1997/98. Between 1995 and 1999, the consumption of fertilizer increased from 35,272 to 2,168,756 quintals. In the same period, improved seed application rose from 11,043 to 177,783 quintals. The number of participating farmers leaped from 31,256 to 3,731,217 covering nearly 40% of the farming population The value of credit, which began at 8.1 million, has reached 150.2 million. Demonstration plots in the fields of farmers covered by the package rose to at 3,807,658. In terms of its spread in hitherto unknown areas, adoption rates of new varieties & fertilizer, diffusion and increased yield rates resemble green revolution in cereals (Tenkir, et al., 2004).

Given the state of agricultural productivity in Ethiopia, the scene of the technology diffusion and adoption has to change the production frontier of farmers. To this end while some indicators of adoption levels have been treated to some extent, however, its effect on the level of productivity has not been sufficiently addressed by researchers. This study therefore aimed at contributing towards this end thereby looking into the impact of the technology packages on the productivity & technical efficiency of farmers in Ethiopia.

2.Objective of the Study

The study has the following general and specific objectives.

1) To assess the total factor productivity the performance of extension participating farmers in comparison to non-extension farmers.
2) To estimate the technical efficiency for both extension and non-extension farmers[1] and identify determinants.

3. Methodological issues: Conceptual Framework

3.1 Total Factor Productivity (TFP)

The economic theory of production has provided the analytical framework for most empirical research on productivity measurement. The cornerstone of the theory is the production function, which postulates a well-defined relationship between output and factor inputs. Productivity can be achieved from two sources; first, through technological change of using improved practices of production such as ploughs, fertilizers, pesticides, improved seeds, etc which pushes the production frontier upward; and second, if the farmer has got further skills in using the existing techniques of production, productivity will increase.

Measuring productivity is conceptually better understood when total factor productivity (TFP) is measured empirically. Total factor productivity is the ratio of aggregate outputs to aggregate inputs. Some studies use interspatial measures of total factor productivity based on *Divisia Index* as defined by Denny and Fuss (1980), where efficiency is estimated for different kinds of land contracts. The TFP approach is found to be suitable for cases where the complexity and diversity of smallholder farming, like in Ethiopia, is large; it also makes comparison possible among different farming systems. The superiority of the method of TFP over the conventional method of measuring land and labour productivity emerges from the fact that the later is misleading if there is high substitutability between inputs (Gavian and Ehui, 1996). Within the TFP methods, there are different kinds of measurement techniques that need to be seen from various methodological perspectives.

Most of the empirical literature dealt so far focused on productivity of individual factor productivities in Africa such as labour and land productivities and some of those studies got strong evidence that fertilizer and improved seeds are associated with higher yields; and considerable yield variability across fields within a given technology type (Howard et, 1999). Reardon et al 1996, also, indicated that returns per labour day and output per hectare of wheat maize and soybeans are generally low for some African countries and the yields differ by crop, zone, technology and farm size; determinants of productivity

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[1] Technical efficiency is the ability of a firm to obtain maximal output from a given set of inputs while alocative efficiency is the ability of a firm to use inputs in optimal proportions, given their respective prices (Coelli, 1995).

according to this evidence are many.[2] Moreover, they indicated that policy reform (exchange rate, interest rate and market liberalization) is necessary but not a sufficient condition to spur productivity.

Another study in Ethiopia revealed that tenure difference in terms of "rented-in" and "owned" has significant effect on sorghum and wheat productivity while there is no significant impact on teff and maize (Abebe and Negussie, 2005). The same study revealed that at regional level land fragmentation (number of parcels) and land conservation has positive relationship with the sample crops yields, remarking a possible difference at zonal level in the case of land fragmentation. An empirical study using discriminant analysis of participants and non-participants in extension package program in Oromia region indicates that the yields of maize and wheat from plots of National Extension Package participants as compared to non-participants in the study area is found to be as high as 50% for maize and 39% for wheat compared to yields of the same crops from the non- participant farmers, with insignificant difference for teff and sorghum (Samia and Habe, 2005). However, most of those studies conducted earlier in Ethiopia, have focused on the technical efficiency, and not so much on factor productivity. In this regard, one of the most commonly adopted indexes of measurement of TFP is the Tornqvist quantity index, shown below.

The Tornqvist Index

$$\ell n\mathrm{TFP}^{*}_{st}$$

$$= \left[\tfrac{1}{2} \sum_{i=1}^{N} \left(\omega_{it} + \overline{\omega_i}\right)\left(\ln y_{it} - \overline{\ln y_i}\right) - \tfrac{1}{2} \sum_{i=1}^{N} \left(\omega_{is} + \overline{\omega_i}\right)\left(\ln y_{is} - \overline{\ln y_i}\right) \right] -$$

$$\left[\tfrac{1}{2} \sum_{j=1}^{N} \left(\upsilon_{jt} + \overline{\upsilon_j}\right)\left(\ln X_{jt} - \overline{\ln y_i}\right) - \tfrac{1}{2} \sum_{j=1}^{N} \left(\upsilon_{js} + \overline{\upsilon_j}\right)\left(\ln X_{js} - \overline{\ln y_i}\right) \right]$$

Where: TFP_{st}* is a transitive TFP index and

$\overline{\omega_i}$ = arithmetic mean of output shares;

$\overline{\upsilon_j}$ = arithmetic mean of input shares; P_{it} and Q_{it} are price and quantity of commodity **i** at time **t** respectively.

$$\overline{\ln y_i} = \frac{1}{M}\sum_{k=1}^{M} \ln Y_{ik}, \text{ and}$$

$$\overline{\ln y_i} = \frac{1}{M}\sum_{k=1}^{M} \ln X_{ik}$$; all averages are taken over the M enterprises or time periods or a combination of both.

The estimated value of the index tells us the direction of change of TFP (Collie, 1998). In this study, first the TFP has been estimated followed by linear regression model to

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[2] Fertilizer, seed, animal traction, organic inputs & conservation investments, farm size and land tenure, non-cropping income (including credit), land preparation efforts and wel-functioning input & output markets.

identify factors influencing TFP; as was applied in some studies on Ethiopian agriculture (Abate and Gezahegn, 2002).

3.2 Technical Efficiency

In estimating the frontier, we use the model derived by Battese & Coelli (1993,1995):

$$\mathbf{Y_i = F(X_i; \beta) + \varepsilon_i\,;\ \varepsilon_i = V_i - U_{i;}\ \text{where } U_i \geq 0}$$

Where, $Y_{i:}$ output of the farm i=1,2,…N

F (…): is the production technology

X is vector of N inputs

β is vector of unknown parameter to be estimated

ε_i is the error term with two components of:

V_i : is non-negative error term(due to the decision or action of the farmer);

U_i: the technical inefficiency component (factors out of control of the farmer / decision maker.

$U_i = \sum \delta Z_i + \omega_i$, $U_i \geq 0$; where Z_i factors affecting the technical efficiency of the farm and δ is parameter.

The symmetric random error V_i accounts for random variations in output because of factors, such as, measurement error, exogenous shocks; etc, which is not under the control of the farmer and it is assumed to be independently and identically distributed as N $(0,\sigma^2_{vi})$. Moreover, the asymmetric non-negative random error, U_i measures technical inefficiency relative to the SF and is assumed to be to be independently and identically distributed non-negative truncations (at zero from below) of the N (μ, σ^2_{ui}) distribution. The variance parameter of the model is parameterized as:

$$\sigma_\varepsilon^2 = \sigma_u^2 + \sigma_v^2 \quad \textbf{and } \gamma = \sigma_u^2 \,/\, \sigma_u^2;\ \mathbf{0<\gamma<1:}$$

$\tilde{y} = y_i - u_i = f(x_{i;}\ \beta) - v_i$, after finding the estimates of u_i and $v_{i;}$

Where,

$\tilde{y}$: is the observed output of the ith farm household adjusted for the stochastic random noise captured by $u_{i;}$ this equation is used to derive the technically efficient input vector and to derive algebraically.

The model we use matters in measuring the efficiency of firms (Liu, 2005). There are two common functional specifications the Cobb-Douglas stochastic frontier & the translog. Cobb-Douglas is production function is criticized for its rigidity flexible despite the multi-colinearity problem. The functional form of the stochastic frontier is determined by testing. Thus, the frontier models estimated are defined as:

$$y_{it} = \beta_o + \sum_{j=1}^{n} \beta_i X_i + V_{it} - U_{it} \qquad \text{(Cobb-Douglas) ; and}$$

$$y_{it} = \beta_o + \sum_{i=1}^{p} \beta_i X_i + \sum_{j=1}^{p} \sum_{i=1}^{p} \beta_{jh} X_i X_{hj} + V_{it} - U_{it} \quad \text{(Translog).}$$

We select the appropriate model specification through tests. Wald tests are commonly used parametric test for testing the null hypothesis of no inefficiency, i.e., that the variance of the one-sided process assumes zero. However, additional Monte Carlo experiments show that the size properties of this test are very weak (STATA, 2003). The estimation of truncated-normal distribution stochastic frontier model and the log likelihood test makes continuous iteration and attaches the maximized iteration, which is used to calculate the log likelihood statistics. The likelihood-ratio test statistic λ = -2{log [Likelihood (H_o)]– log [Likelihood (H_1)]} has approximately a χ_q^2 distribution with q equal to the number of parameters assumed to be zero in the null hypothesis; it is compared with the critical values of the χ_q^2 _distribution and decided between the two models. The power of the LR test is increased by testing jointly the null hypothesis that $\gamma = \delta_i = 0$, for all i, meaning that neither the constant term nor the inefficiency effects are present in the model; since γ takes values between 0 and 1, any LR test involving a null hypothesis which includes the restriction that $\gamma = 0$ has been shown to have a mixed χ^2 distribution, with appropriate critical values (Kodde and Palm, 1986) as quoted in Piesse, et al (2002).

The technical inefficiency effect term is distributed N (μ_i,σ^2_v) where μ_i can be specified and defined as:

$$\mu_i = \beta o + \sum_{j=1}^{n} \delta_o Z_{ij}$$; where Z_j are socioeconomic & infrastructure variables which are identified in the literature or taken from the observation of the researcher.

The estimation of the inefficiency model has two approaches. The first is simultaneous equation modeling (Battese & Coelli, 1995) and the two-stage modeling (discussed above). The advantage of the simultaneous equation technique over the two stages is that it incorporates farm specific factors in the estimation of the production frontier because those factors may have a direct impact on efficiency (Wadud, 2002). The estimates for u_i & v_i are found from the SF model & the technical efficiency predictors by replacing parameter by their maximum likelihood estimates. We use the maximum likelihood estimation to identify the determinants, though the choice of model is often controversial (Batsse et, 1995).

3.3 The Data

For this study, the May 2001/02 survey data generated by EDRI was combined with the survey data collected during the same period by the Central Statistical Authority's (CSA) on Ethiopian Agricultural Sample Enumeration extension package data, mainly for the yield data[1].

The sampling method used is systematic sampling, which includes random selection of farm households in the order of zones from the four major regions of the country, which represents over 85% of the population. Two woredas were selected from each zones depending on the level of adoption of modern input technology. Within the woredas, PAs are randomly selected through stratified sampling, and then farm households are selected randomly through systematic sampling. As the objective of this study is to estimate Total Factor Productivity (TFP) and Technical Efficiency (TE), we took the sample for each crop out of the national sample of 1921 farm households (Agricultural Extension Survey

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[1] The yield data from CSA is based on a more accurate measure of yield index using crop-cut samples

of EDRI of the 2001/02); until we get complete data set on the variables required to estimate TFP differential between extension & non-extension farmers *(Tornquvist index)*, we continuously reduced the sample size and finally we arrive at the matching sample size for each crop i.e. 115 for maize, 55 for wheat and 112 for teff. For technical efficiency estimation, however, the sample size is relatively larger i.e. 186 for maize & 244 for teff.

4. Socioeconomic and demographic Characteristics of Farm Households

Table-1 depicts the socioeconomic and demographic characteristics of sampled households. Household size has no significant effect between extension and non-extension farmers, although higher mean values for extension farmers in case of wheat and teff production were observed. Teff and wheat are relatively more labour and technology intensive. The number of livestock the households own has mixed features; first, for maize and wheat farmers, the average number of livestock is higher for adopters, which may show the relatively higher income that may lead to purchase the input packages. On the second level,, the number of livestock in case of teff is higher for non-extension farmers, (standard deviation is for extension farmers 12.10 compared to 35.44 that of non-extension farmers).

Table-1: Extension & Non-extension Farmers: Quantitative Variables

Corp/variable	**Extension**			**Non-extension farmers**		
Maize (Maximum N=115)	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
Age of Head	41.94	14.33	40.00	44.00	14.00	40.00
Household size	6.28	2.17	6.00	6.0	2.00	6.00
No of Male	3.50	1.93	3.00	3.00	1.00	3.00
No of Female	2.97	1.66	3.00	3.00	1.00	3.00
No of livestock	5.44	4.68	4.00	4.48	3.48	3.00
Wheat (Maximum N= 55)						
Age of Head	43.21	13.89	44.00	45.64	16.72	43.00
Household size	5.75	2.09	6.00	5.32	1.65	5.50
No of Male	3.14	1.53	3.00	3.00	1.29	3.00
No of Female	2.63	1.45	2.00	2.32	1.11	2.00
No of livestock	5.40	4.17	5.00	4.33	3.00	3.07
Teff (Maximum N=112)						
Age of Head	**47.0**	**13.00**	45.00	45.00	14.00	46.00
Household size	6.00	2.00	6.00	5.00	2.00	5.00
No of Male	3.00	2.00	3.00	3.00	2.00	3.00
No of Female	3.00	1.00	3.00	3.00	1.00	2.00
No. of livestock	8.51	15.19	6.00	12.50	5.09	5.00

Source: Own Summary from Extension Data

From the table 1, one may infer the following important features; first, the proportion of female household head for the crops producers with larger sample size (maize and teff) is higher in the non-extensions (15% for maize and 13% for teff) against 9% and 12% for extension farmers respectively. At the second level,the national average female percentage for all crops in the extensions and non-extension farmers stands at about 8% and 12% respectively. In the sample, the proportion of illiterate farmers is about 56%, 47% and 56% for maize, wheat and teff extensions respectively while it is 73%, 80% and 67% for non-extension farmers of the same crops respectively. This shows that less number of extension farmers are illiterate which is true for more of non- extension farm households. This reflects that there is an overall tendency for educated farmers to adopt new technologies, which is consistent with the findings of previous studies (EDRI report 2, 2004). In addition, most of the farm households included in the sample are followers of orthodox Christian religion (average of 65% for all crops); this is indeed twice the national average figure in the national sample (i.e. 31.5%).

Table-2: Extension & Non-extension farmers: Qualitative Socioeconomic Variables

Corp/variable	Adopters		Non-extension farmers	
Maize (N= 115)	**Sample Highest Share**	**Sample Lowest shares**	**Sample Highest Share**	**Sample Lowest shares**
Sex of Head (1=M & 2=F)	M=106 (92%)♠	F=9 (8%)	M=96(83.5%)	F=28(16.5%)
Marital Status[3]	1=107(93%)	3=5,4=1,5=1	1=94(82)	All others=21
Religion[4]	1=57 (50%)	2=35, 4=20, 3=2	1=42(37%)	2=40;3=1;4=32
Education of Head[5]	1=61(50%)	2=13,3=17,4=24	1=83(72%)	2=6;3=19;4=7
Means of livelihood[6]	Farming=114	Education =1	Farming=115	Education =0
Wheat (N=56)				
Sex of Head	M=54(96%)	F=2(4%)	M=54(96%)	F=2(4%)
Marital Status	1=54(96%)	5=1;6=1	1=50	2=1;3=2;4=2;5=1
Religion	1=31(55%)	2=25	1=34	2=21;3=1
Education of Head	1=29(52%)	2=14;3=9;4=4	1=43	2=7;3=4;4=2
Means of livelihood	Farming=56	-	Farming=56	-
Teff (N=112)				
Sex of Head	100(89%)	F=12(11%)	M=96(87%)	F=16(14%)
Marital Status	1=101(90%)	3=5; all others 6	1=92(82)	3=10; all others=12
Religion	1=88(79%)	2=14,3=4;4=4;	1=79(71)	2=22;4=11
Education of Head	1=66(59%)	2=17;3=18;4=11	1=78(70)	2=12;3=15;4=7
Means of livelihood	Farming=110	2=1; 6=1	Farming=111	3=1

Source: Own Summary from Extension Data

4.1 Input use

Input use is important determinants of the level of output though not a sufficient condition in its own.Household farmers use different types of inputs for the farming practices. However, the level and intensity of use differ among and between the farmers. In this study the most commonly used inputs are fertilizer and seed for wheat , teff and maize production.

4.1.1 MAIZE

The average land size allocated for maize by adopters' is about 0.37 ha (max: 2.0 and a min: 0.06 ha). In comparison, the average land size of the non-extension farmers is 0.34 ha ranging within a maximum of 1.5 ha and a minimum of 0.12 ha (Table-3).

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[3] 1 =Married; 2= Unmarried; 3= Widow; 4= Widower; 5= Divorced; 6= Migrant HH; 7= other 8=unknown

[4] 1=orthodox; 2=Muslim; 3=Catholic; 4= Protestant

[5] 1= Illiterate; 2= Grade 1-6; 3= Grade 7-12; 4= above grade 12

[6] 1= trade; 2= education; 3=hired out labour; 4= living with relative; 6=others

Table-3: Input Usage by Sample Maize Extension and Non-extension Farmers

Item		Extension					Non-extension				
		N	Min	Max	Mean	Std	N	Min	Max	Mean	Std
Land Size		115	0.06	4.0	0.46	0.5	115	0.12	1.50	0.34	0.2
Total Urea & DAP (Kg)		115	4.00	400	71.82	65.5	115	0	0	0	0
Improved Plus Local Seed	Total	88[7]	0.25	50.0	9.0	7.4	115	0.25	90.00	8.9	6.8
	Only Selected seed	71(62%)	0.25	50	8.4	8.3	115	0	0	0	0
	Only Local seed	28	.5	19	6.9	4.2	115	0.25	90.00	8.9	6.8
	Both (sum) users	11	5	27.5	15.9	7.1	115	0	0	0	0
Natural Fertilizer (Kg)		18	0.50	200	93.7	67.6	1	2.00	2.00	2	0
Chemical Expenditures		46	10.00	78	13.7	19.9	115	0	0	0	0
Receive Advice Offered?		Y=65, n=14	-	-	-	-	Y=14	-	-	-	-
Total No of OXEN		115	0.00	5	1.51	1.16	115	1.00	5.00	1.11	0.7
Total *OTD*s		115	0.74	64	11.6	11.0	115	0.75	38.00	8.9	6.8
Labor in man-days		115	2.00	228	48.8	42.0	115	3.50	113.75	34.06	22.4

Source: Own computation from Extension Data

There is high variation in the fertilizer use among extension farmers. It varies from a maximum of 400 kg to a minimum of 4 kg, with an average of 71.8 kg. Among the adopters, there are 18 (only 15.6%) who utilize natural fertilizers in addition to the artificial ones. When we see the seed input-use by the sample extension maize producers 71(61%) responded to have used improved seed, 65(24%) of them use only local seeds 9.5% of them use a mixture of both types of seeds. Obviously, the non-extension maize producers use local maize seeds. It is believed that farmers use chemicals for pesticides, weeds, etc; however, in the sample there are 46(40%) extensions and no non-extension farmers using chemicals in maize production. The other component is advises and follow-up offered by the local extension agents on inputs, cultural practices, chemicals and others. To the question asked on whether the adopter is getting advice offered with respect to all crops, 65 extension farmers (56.5%) responded to have used input/advice and advice on cultural and other practices while 50(43%) of them didn’t receive any types of extension advice. This is similar for all of the three crops extension adopters, but varies for the non-extension farmers (10%, 21% and 16 % for maize, teff and wheat non-extensions).

The traditional crop production involves use of draught power input of oxen. In this regard, the number of oxen the farmers own affects their production. In the maize sample respondent extension and non-extension, 49 among N=78 (63%) and N=37 among N=84 of them (44%) have two or more oxen respectively. The larger percentage of more than

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[7] The remaining are reported as missing data

two oxen extension farmers owners as compared to non-extension consistent with the sample size of 186. This shows that more extension participating farmers have the required number of oxen for tilling and adopting technologies compared to the non-extension farmers. The number of farmers with no oxen ownership is also greater for the non-extension 46(40%) than that of Extension 37(32%) farm households. In terms of the total *OTD* used, for extension and the non-extensions the mean is 11.6 (*min: 0.74 & max: 64)* and *8.9 (min: 0.75 & max: 38)* respectively, which depicts that more intensive in cultivation for extensions. The characteristics of labor input indicates similar trend. The average labour input for extension farmers is 48.8 AE within a range of 2.0 to 289 man-days while for the non-extension the mean is 30.9 in the range of 3.5 to 113.8 man-days, which remarks the need for higher labour input in adopting modern technologies**.**

Two more variables included in this descriptive analysis are the credit and market access. Theoretically it is believed that better access to market derives farmers to be more productive and efficient thereby opening market opportunities. Among the 115 non-extension maize farmers, 5 (4%) use all, 19 (17%) use primary and secondary while 91(79%) use only primary maize markets, which is remarkably lower market visit than the case of non-extension. The non-extensions farmers on average attend less number of markets (primary, secondary and tertiary), but more frequently than the extension. Most of the non-adopter maize farmers use the primary market with the average attendance frequency of 1.4. On average, extensions attend primary, secondary and tertiary markets at a rate of 1.44, 1.36 and 1.39 times per week; while the non-extensions do 1.44, 2.10 and 1.46 per week respectively (Table-4). Secondary markets are more often visited than any other markets by the non-extension farmers.

With a larger sample size of 186 maize extensions (non-matching sample), only 23(12%) of them use all primary, secondary and tertiary markets; 75(40%) use primary and secondary markets while 84(45%) use only primary markets[8]. The data shows non-extensions on average go to visit less number of markets (primary, secondary and tertiary) but more frequently than the extension. Among the 117 non-adopter maize farmers who responded to the question of their maize markets, 4 (3%) use all, 31% use primary and secondary while 66% use only primary maize markets, which is lower market usage than the case of adopters. Most of the non- extension maize farmers use the primary market & the average maize market attendance frequency is 1.4.

Table 4. Maize Markets, average Distance and Frequency of Attendance

Market		Extension	Non-extension
1	Usage[9] (P, S, T)	P=85(74%); S=22(19%); T=5(4%)	P=91(79%); S=19(17%); T=5(4%)
2	Mean Distance	4.6, 9.9 & 11.3 respectively for P, S, T	6.7, 11.7 & 9.9 respectively for P, S, T
3	Mean attending Freq. per week	1.44, 1.36 & 1.39 respectively for P, S, T	1.44, 2.10 & 1.46 respectively for P, S, T

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[8] The average distance for the primary secondary and tertiary markets is about **5.7, 9.5 and 11.2 kms** respectively (according to extension farmers), with a respective average attendance frequency of **1.8, 1.9 and 1.4.**

[9] P= primary, S= secondary, and T=tertiary

In extension package program the role of credit is very important to integrate the input market and technology adoption. The 115 maize extension response shows that the farmers are more credit users than the non-extensions farmers nearly in all the crops. Among 98 extensions that responded to the question of finance on input financing, 39(40%) farmers get access to credit to finance their maize inputs (fertilizers and/or seed), 48(49%) use their own income to purchase inputs. Here, most of the farmers tend to borrow for financing fertilizer input (on average 66%) as compared to financing seed (52%), due to the possibility of using local seed instead of improved seed. A related assessment is made on access to credit. The response of the farmers shows that of all the farmers receiving credit, the performances of the agents in relation to importance of delivery of credit was rated (on average 74% of the extensions), the Peasant Association assess 14%, the input committee 2%, woreda 4% and others assess 7%.

4.1.2 TEFF

Teff is the most widely adapted crop compared to any other cereal or pulse crop in the country and can be grown under wider agro-ecologies (temperature and soil condition). The average land size allocated is 0.67 ha (max: 3.0 & min: 0.06ha), which is relatively higher variation compared to that of maize. Similar to the case of maize, the average land size is larger for extension compared to that of non-extension, which is 0.51 (max: 2.5 & min: 0.06 ha). The use of fertilizer input in teff varies considerably among farm households. with a mean of 62.3 kg per ha. The mean is lower than the case of maize, but there is higher standard deviation in maize (Table-5); which shows that the average productivity variation among the farmers. Maize is general responds better to fertilizer input than any other crops leading to productivity changes for the extension farmers using more fertilizer inputs. The higher fertilizer input the higher is the return i.e. increasing returns to scale, whereas teff has some limit to fertilizer application; this is in consistent with previous studies in Ethiopia (Hailemariam et al, 2006).

Table-5: Input Usage by Sample Teff Extensions and Non- Extensions Farmers(N=112)

Item		Extensions					Non-extensions				
Maize		N	Min	Max	Mean	Std	N	Min	Max	Mean	Std
Land Size		112	.06	2.75	0.64	0.4	112	0.06	2.50	0.6	0.42
Total Urea and DAP (Kg)		112	2.68	200.00	55.6	34.0	0	-	-	-	-
Selected & Local Seed	Total	112	2.00	150	31.1	27.2	112	0.16	160.0	29.0	25.7
	Only Selected seed	7	6	25	14.4	5.8	0	-	-	-	-
	Only Local seed	105	2	150	32.2	27.7	112	0.16	160.0	29.0	25.7
	Both SS+LS users	0	-	-	-	-	0	-	-	-	-
Natural Fertilizer (Kg)		4	10	100	46	39	0	-	-	-	-
Chemical Expenditure (birr)		30()	3.00	120.00	37.4	25.7	0	-	-	-	-
Receive Advice Offered?		Y=59,no=11		-	-	-	47	-	-	-	-
Total No. of OXEN		112	.00	5.00	1.9	0.71	112	0.00	5.00	1.60	0.67
Total *OTD*s (oxen days)		112	1.75	161.6	24.6	22.5	112	2.0	60.00	19.5	15.0
Labour in man-days		112	6.55	192.0	62.3	42.7	112	5.1	193.0	56.1	43.2

Source: Extension Data CSA 2001

The numbers of extension that are using improved seed are only 7(6%); this seems very low compared to that of maize (62%) and wheat (18%). The low level of adoption of selected seed in teff is due to the lack of good quality selected seed; particularly teff varieties run out quickly due to mechanical contamination (Mulat, 1999). Teff is usually less susceptible to diseases as compared to other cereals and as a result less chemicals are used; except the need for herbicide chemicals application to protect against weed. Extensions farmers use chemicals (27%) unlike all of the non-extensions (Table-5). The total number of oxen owned by teff extension varies from 0 to 5, with average of 1.9 oxen. About 68% of them have 2 or more oxen; this figure is larger compared to the total number of extension farmers included in the national sample i.e. (22%) but close to some village level survey results (Holden, 2004). Extensions with no ox are only 6.3%, which is very low compared to the case of maize (32.2%) and 16% to wheat extensions. The range of no oxen is not significantly different for non-extension, 27% for maize, 20.5% for teff and 28.6% for wheat. When we compare the oxen Timad Days (*OTD)* and labour (in man-days)- the mean value found in all crops is greater for extension than that of non-extensions (Tables-3, 5 and 6) in estimating in total factor productivity and efficiency parameters.

4.1.3 Wheat

The average land size for wheat extension and non-extensions farmers stands close to 0.5 and 0.35 ha respectively, which is less than the comparable magnitude of land size for maize and tefft The average wheat land-size is 0.43 and 0.57 for extensions and non-extension farmers respectively.(it has higher difference for non-extension farmers due to the fall in the sample proportion of SNNPR that has the highest average land size in national sample[10].). Regarding fertilizer use, the average fertilizer use is 53 kg, (Table-6); the average which is below that of an average of both maize and teff. However, this average figure coincides with that of the national average for wheat sample. In terms of the improved seed use, low percentage of extension farmers are using selected seed compared to that of maize. This shows maize technology is the most widely adopted and intensive improved seed applied in the extension system.

Table-6: Input use by Sample Wheat Extension and Non-Extension Farmers

Item		Extension					Non-extension farmers				
		N	Min	Max	Mean	Std	N	Min	Max	Mean	Std
Land Size		56	0.08	3.0	0.5	0.44	56	0.08	1.00	0.35	0.18
Total Urea and DAP (Kg)		56	2.00	400	68.5	67.0	56	-	-	-	-
Selected Plus Local Seed	Total	56	300	100	46.9	22.9	56	1.50	150	44.5	33.83
	Only improved	9	18	100	45.3	23.5	-	-	-	-	-
	Only Local Seed	48	3	100	46.3	22.9	56	1.50	150	44.5	33.83
	Both imp and LS	1	-	-	-	-	0	-	-	-	-
Natural Fertilizer (Kg)		5	1.00	200	200	200	6	20.00	900	261.67	323.14
Chemical Expenditure (birr)		4	8.0	63	38.6	22.7	0	-	-	-	-
Receive Advice Offered? Yes		35	-	-	-	-	9	-	-	-	-
Total No. of OXEN		56	0.00	4	**1.7**	0.72	56	0.00	4	**1.4**	0.54
Total *OTD*s		56	1.00	40	**11.7**	8.05	56	1.00	53.00	**9.97**	9.75
Labour in man-days		56	3.35	160	**31.3**	23.6	56	6.75	125.45	**29.46**	21.62

Source: Extension Survey Data, 2002

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[10] During random selection, only one farm-household is included from SNNPR.

The table 6 shows, about 87% of the wheat extensions farmers are using local seed as compared to 100% in wheat non-extension. This figure is almost comparable to the case of maize non-extension but high localization of improved seed in wheat. Most of the extension (62%) use advice from development agents. The mean oxen ownership in maize extension is higher compared to that of non-extensions (1.7 for extensions vs 1.4 non-extension). This tendency is similar for average OTDs spent on wheat production i.e. 11.7 for extensions (min 3.35 and max 40) and 9 OTDs for non-extensions farmers [min one OTD (0.13 ha land size and max of 53 OTD]. The fact that the value for extension farmers is higher than that of non-extensions is clearly an indication of more oxen input use for maize and wheat. The table also depicts the labour allocation in adult equivalent; the mean labor spent in man-days is 31.3 for extensions and 29.5 man-days for non-extensions, which is also consistent in labour allocation for maize and teff production.

4.2 EMPIRICAL RESULTS OF ESTIMATION

4.2.1 TOTAL FACTOR PRODUCTIVITY

Our estimate for TFP is based on a single output, as the individual extension and non-extension farm households are different for the three crops. This makes the share of output in total output equal to one (or 100%), while the share of quantity of inputs in total value of inputs is calculated for all the three crops.The value of inputs considered in this case are value of fertilizer, Oxen days (OTD) and labour calculated as a share of the value of each input in the total value of inputs. The ***Tornqvist TFP Index,*** *by* its nature is defined as the output index divided by the input index; the natural logarithm the TFP is therefore the difference between the natural logarithm of output index and the natural logarithm of the input index. Both the output and input indices consider quantity of output and quantity of input, except that input for both extension and non-extensions is weighted by the share of the value of each input in the sum of value of all inputs (Collie, 1998). As the estimated index indicates, in the analysis the difference between extension and non-extension output and input usage has been considered as we are basing our estimate on cross-sectional data. When the index value for two households (where one is extension and the other is non-extension) is below 1.0, it implies the TFP falls from extension to non- extension farmer by a percentage equal to the difference multiplied by 100. Similarly, if the estimated TFP is below or greater than 1.0, the TFP increases from adopter to non-extension farmers by some percent (Collie et al 1998). The estimate of the TFP for maize, teff & wheat is summarized in Table-7.

Table 7. Estimated Total Factor Productivity Difference for Maize, Teff & Wheat [*Tornqvist TFP Index*]

Category	Maize		Teff		Wheat	
Number of ΔTFP < 1.000	**74**	**65%**	73	65%	53	96%
Number of ΔTFP > 1.000	**34**	**30%**	30	27%	2	4%
Number of ΔTFP = 1.000 (0.95-1.05)	**7**	**6%**	9	8%	0	0%
Minimum	*0.101*	-	*0.152*	-	*0.122*	-
Maximum	*1.954*	-	1.914	-	1.602	-
MEAN ΔTFP	*0.801*	-	*0.853*	-	*0.364*	-
Standard Deviation	0.414	-	0.435	-	0.290	-

Sample size	115	99%	112	100%	55	100%

Source: Summarized Estimation

Table-7 depicted that on average in 65% of the cases TFP increases when we move from non-extension to extension maize producers; while there is no significant difference in TFP between extensions and non-extensions for 6% of the cases. For maize producers, compared to the other two crops, there is a sizeable difference in TFP level between matching cases (farmers from different PAs), perhaps implying there is high technological diffusion in case of maize; and second, agro-ecological difference largely influences TFP differences in maize, and this is less important in the case of teff. However, for wheat, as we can see from the table there is a significant difference in TFP for the same case (matching and non-matching). This shows either there is less diffusion for wheat technology or more importantly, fertilizer makes difference in TFP. The later sounds as there is high diffusion for-improved seed wheat with high possible variation in fertilizer application and soil texture.

Further more, the estimated result reveals that on average TFP falls from extension to non-extension by 20%, 15% and 60% in matching cases for maize, teff and wheat respectively. The trend is that in majority of the cases there is a rise in productivity from non-extensions to extensions. Basically, the level and type of input usage and the level of diffusion of technologies between extensions and non-extensions determines the level of TFP. Moreover, the output and productivity of maize & wheat, is affected by the difference in an on-farm application of improved seed, while for teff this may not be as important as improved seed, which may have less impact due to high physical contamination of seeds. Fertilizer input, agro-ecology, soil fertility, and other socioeconomic factors may contribute to the difference in TFP. In case of wheat, fertilizer application which is major input in wheat production brings about a remarkable difference between extensions and non-extensions rather than improved seed itself. The multiple regressions model is employed to identify the TFP determinants and TFP difference as follows.

$$\begin{aligned}TFP_i = {} & \alpha_0 + \alpha_1\mathbf{LABOUR}_i + \alpha_2\,\mathbf{OXTIMDAYS}_i + \alpha_3\,\mathbf{QFERT}_i + + \alpha_4\mathbf{QSEED}_i + \\ & \alpha_5\mathbf{LANDSIZE}_i + \alpha_6\mathbf{HHSIZE}_i + \alpha_7\mathbf{NOFEMALE}_i + \alpha_8\mathbf{NOMALE}_i + \\ & \alpha_9\mathbf{DISTPRMKT}_i + \alpha_{10}\,\mathbf{PRICE}_i + \alpha_{11}\,\mathbf{EXTADVS}_i + \alpha_{12}\mathbf{NLS}_i + \alpha_{13}\mathbf{SEX}_i + \\ & \alpha_{14}\mathbf{AGE}_i + \alpha_{15}\mathbf{EDUDMY}_i + \alpha_{16}\,\mathbf{RELIGDUMY}_i + \alpha_{17}\mathbf{REGIONDMY}_i + \\ & \alpha_{18}\mathbf{WOREDDUMY}_i + \varepsilon_i\end{aligned}$$

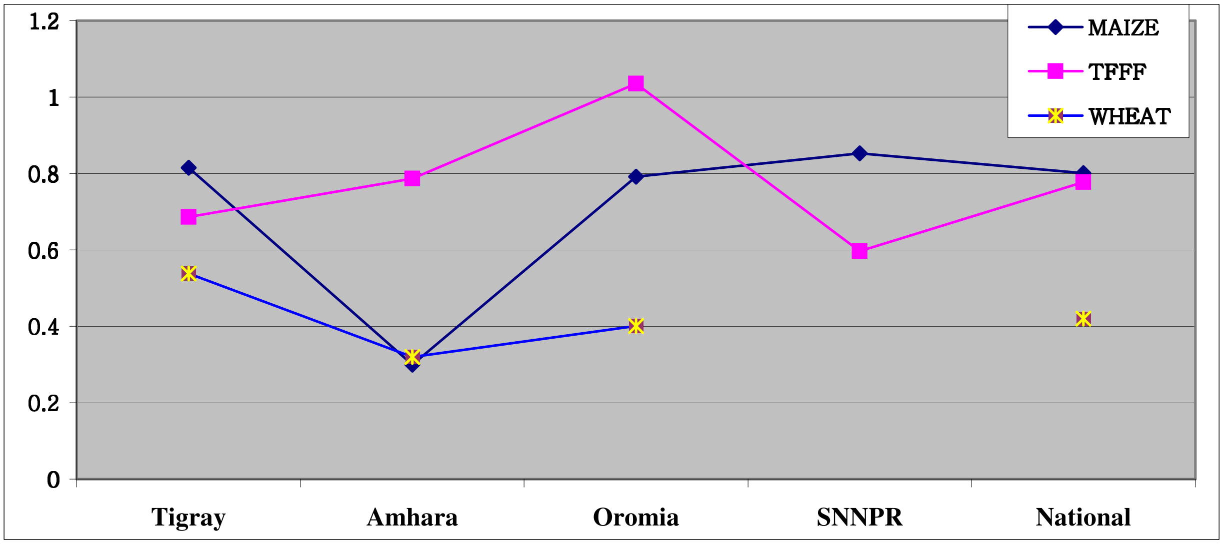
Where, **LANDSIZE**:Land size; **HHSIZE**: Household Size; **LABOR**: Labour in adult equivalent; **NULIVSTOK:** livestock size; **SEX:** Sex; **DISPRIMKT**: Distance from primary market; **NUMALE:** Number of male; **NUFEMALE:** Number of female; **QSEED:** Quantity of seed; **QFERT:** Quantity of fertilizer; **PRICE:** output Price; **AGE:** Age; **EXTADVIC:** Access to Extension advise; **EDUCDUMY:** Education Dumy; **RELIGDUMY**: Religion Dummy; **REGDUMY**: Region dummy; **WORDUMY**: Woreda dummy; $\boldsymbol{\varepsilon_i}$: error term, $\varepsilon i \sim N(0,\delta^2)$.

As shown in Table 8, the variation is indicated through TFP differences among regions. Relatively higher difference is observed between extension and non-extension farmers in mean TFP in wheat production, with an average TFP differences of about 58%. The least variation is seen in maize production (18% excluding Amhara region) followed by teff (23%). In all crops, most of the TFP of extension farmers exceeds that of the non-extension farmers (by 67%, 79% and 96% of the cases in maize, teff and wheat respectively)- Figure -1.

Table 8: Mean TFP Differences between Extension & Non-extension among Regions

CROP	Region:	Mean	%>(Mean=1.0)	N	Std. Dev
MAIZE	Tigray	0.815		18	0.07
	Amhara	0.300		1	-
	Oromia	0.792		68	0.373
	SNNPR	0.853		28	0.379
	Av. Total	**0.801**	**67%**	**115**	**0.405**
TEFF	Tigray	0.686		37	0.397
	Amhara	0.787		16	0.468
	Oromia	1.035		51	0.397
	SNNPR	0.597		8	0.390
	Av. Total	**0.777**	**79%**	**112**	**0.185**
WHEAT	Tigray	0.538		6	0.321
	Amhara	0.320		35	0.236
	Oromia	0.401		14	0.376
	SNNPR	-		-	
	Av. Total	**0.420**	**96%**	**55**	**0.110**

Figure 1: MEAN REGIONAL TFP: MAIZE TEFF AND WHEAT



From the summary (Table 9) we can infer that distance from primary market, Oxen days (OTDs) per hectare, age Land size, Labor in adult equivalent and the agro ecology variable (regional dummy) variables are important determinants of TFP differences between extension and non-extension farmers. The other variables are less important in terms of their contribution to TFP and hence do not not need further analysis.

Table 9: Summary Determinants of Total Factor Productivity: Maize, Teff, Wheat

Variable	Adopters			Non-extension farmers		
	Maize	Teff	Wheat	Maize	Teff	Wheat
Age	√(-)		√(-)			√(-)
Distance from primary market			**√(+)**	**√(+)**	**√(+)**	
Number of male		√(+)				
Number of female						√(+)
Access to Extension advise	√(-)					
Quantity of seed			√(-)			
Quantity of fertilizer	√(-)		√(-)			
Price of Output		√(-)				
Per hectare *OTD*	**√(-)**	**√(-)**	**√(-)**	**√(+)**	**√(+)**	**√(+)**
Number of livestock	√(-)					√(+)
Land size	**√(+)**	**√(+)**	**√(+)**	**√(-)**	**√(-)**	**√(+)**
Household Size		√(-)	√(+)			
Labour in adult equivalent	**√(-)**	**√(-)**	**√(-)**	**√(+)**	**√+)**	**√(+)**
Total Oxen-tmad-days		**√(-)**		**√(+)**	**√(+)**	
Education Dummy				√		
Religion Dummy						√
Region dummy	√			√	√	
Woreda dummy	√	√			√	√

A study revealed that technology (fertilizer and improved seed), environmental factors (soil) & farm management practices (planting time, spacing, frequency of plowing) determine maize yield; and fertilizer application, farmer assessment of soil fertility and soil colour, frequency of plowing (negative relationship with teff yield contrary to maize), and farmer's decision on technology choice are determining teff yield. In general the results from the study are consistent with other studies conducted elsewhere (e.g Howard et al, 1999).

4.2.2 TECHNICAL EFFICIENCY

The scond set of estimation followed from TFP estimation is the technical efficiency measurement. Efficiency can be measured with various kinds of measurement and sophistication. However, the kind of model employed for a particular measurement often depends very much on the desired objectives of the study. In our case here we employed the stochastic frontier model type for its best fit in our data set on the basis of test conducted.

For estimation of the technical efficiency, we specified the model as follows:

$$\mathbf{LnQ= F\,(LANDSIZE_i\,,\,OXTIMDAYS_i,\,LABOUR_i,\,QFETILIZi,\,QSEED_i)} + U_i - V_i$$

Where: LANDSIZE is the plot size; OXTIMDAYS is the number of OTDs spent; LABOUR is quantity of labour; QFETILIZ is quantity of fertilizer applied; and QSEED is quantity of seed used; and

$$|U_i| = \delta_o + \delta_1\mathbf{LLANDSIZE_i} + \delta_2\mathbf{LOXTIMDAYS}i + \delta_3\mathbf{LLABOUR_i} + \delta_4\mathbf{LQFETILIZ_i} + \delta_5\mathbf{LQSEED}_i \text{, and } V_i \sim N(0, \sigma^2)$$

The estimation result of the stochastic frontier model is depicts that the WALD test and the log-likelihood statistics both rejected ***translog*** in favour of ***Cobb-Douglas*** stochastic frontier at 1% level of statistical significance for all estimations (Table_10).

Table 10: Estimated Technical Efficiency (Normal/truncated-Normal distributions)

Variables (Dependent LQOUTPUT)	Stochastic Frontier Estimation results Truncated											
	Maize				Teff				Wheat			
	Extension		Non-extension		Extension		Non-extension		Extension		Non-extension farmers	
	coef	Z- stat	coef	Z- stat	coef	Z- stat	coef	Z-stat	coef	Z- stat	coef	Z
CONSTANT	2.864	∞	3.178	∞	2.53	∞	2.101	19.61	3.210	∞	2.591	∞
LLABOUR	0.179	∞	+0.000	0.01	0.05	2026	0.09	3.55	0.013	113.4	0.322	∞
LOXTIMDAY	0.035	∞	+0.000	0.00	0.14	1432	0.04	1.86	0.002	43.69	0.040	∞
QFERT	0.067	∞	-	-	-0.008	-993	-	-	-0.007	-81.04	-	-
QSEED	-0.085	∞	-0.000	-0.01	-0.02	-∞	-0.012	-1.11	-0.004	-22.11	-0.204	∞
LANDSIZE	0.955	∞	1.000	∞	0.995	∞	0.944	46.05	0.998	∞	0.816	∞
# Observations	186		186		241		241		56		56	
Log-likelihood	-136.58		91.2		103.6		54.4		38.6		-16.7	

Next, the most important test is weather γ=0 or γ=1, the technical efficiency effects are not simply random errors. In other words, we need to test the null hypothesis that there is no inefficiency component. The test result of this estimation, which is based on the z-statistics, shows that except for maize and wheat extension farmers for the rest of the truncated-normal estimations the null is rejected at 1% level of statistical significance while it fails to reject the null in the case of maize and wheat extension farmers (Table_11). For maize and wheat extension farmers therefore we resort to estimating the half-normal distribution and in this case the z-test again rejects the null that there is no inefficiency component at 1% level of statistical significance. Based on these two sets of tests outcomes on the distribution of the inefficiency components, we predicted the technical efficiency for extension and non-extension farmers of the three crops as summarized in Table-11.

Table 11: Technical Efficiency Estimated for Maize, Teff & Wheat Extension and Non-Extension Farmers

TECHNICAL EFFICIENCY	**MAIZE**		**TEFF**		**WHEAT**	
	Extension	**Nonextension**	**Extension**	**Non-extension**	**Extension**	**Non-extension**
Maximum	1.00	1.00	1.00	0.96	1.00	1.00
Minimum	0.15	0.35	0.47	0.48	0.44	0.18
Mean TE	**0.52**	**0.84**	**0.80**	**0.83**	**0.76**	**0.63**
Standard Deviation	0.28	0.21	0.16	0.12	0.22	0.22
Number of FHH >mean	92	142	158	148	25	24
Number of FHH <mean	94	44	83	91	30	31
Sample size	**186**	**186**	**241**	**239**	**55**	**55**

In this estimation we use a sample size of 186 participating extensions and 186-maize non-extension for maize, 241 each for teff and 56- extension and non-extension each for wheat.. We infer from Table-11 that in case of maize and wheat the mean technical efficiency of extension farmers is greater than that of non-extension, while this is not true for the technical efficiency in teff. When we compare the technical efficiency in crops, we see that maize has the highest mean (0.80), with 66% of the sample extension farmers producing above the average. The mean technical efficiency of the non-extension farmers for maize is 0.83 and about 148 (61%) non-extension farmers are operating above the mean. Despite the smaller sample size, the mean technical efficiency of extension farmers is higher than that of non-extension farmers. About 62% of the extension farmers have technical efficiency higher than the mean technical efficiency of non-extensions for wheat with only 43% for non-extensions. Therefore, most of the extension farmers are technically more efficient than the non-extension farmers.

The level of inefficiency by region is reported (Table-12). The table depicts that in most of the six cases inefficiency declines from Southern to Northern Ethiopia. This shows the natural environment influences efficiency in agriculture.

Table-12: Mean Inefficiency of Extension & Non-extension Farmers by Region & crops

Region	Maize				Teff				Wheat				Mean
	Extension		Non-Ext		Extension		Non-Ext		Extension		Non-Ext		
	Mean Ineffi	N	Mean Ineffi	N	Mean Ineffi	N	Mean Ineffi	N	Mean Ineffi	N	Mean Ineffi	N	
Tigray	0.41	11	0.26	47	0.35	47	0.22	63	0.37	11	0.48	5	0.35
Amhara	0.78	80	0.38	5	0.24	67	0.25	70	0.45	19	0.43	34	0.29
Oromia	0.20	68	0.012	94	0.09	57	0.10	94	0.02	19	0.22	14	0.10
SNNPR	0.35	27	0.37	40	0.13	70	0.08	12	-		0.043	2	0.19

In order to determines the technical efficiency of extension and non-extension farmers for the three crops cases as in the proceedings, it is hypothesized that the behavior of the farm household is influenced by environmental and socio-economic variables.

The multiple regression model based on the technical inefficiency effect term is distributed N (μ_i, σ_v^2) where $\mu_{i\ \text{can}}$ be specified and defined as $\mu_i = \delta o + \sum_{j=1}^{m} \delta_o \beta_{ij}$; where β_j are socioeconomic and infrastructure variables which are theoretically or possibly empirically identified variables.

The model:

$$INEF_i = \beta_0 + \beta_1 \mathbf{AGE}_i + \beta_2 \mathbf{SEX}_i + \beta_3\ \mathbf{EDUDMY}_i + \beta_4\ \mathbf{RELIGN}_i + \beta_5 \mathbf{HHSIZE}_i + \beta_6 \mathbf{REGIONDMY}_i + \beta_7 \mathbf{TFP}_i + \beta_8 \mathbf{DISTPRMKT}_i + \boldsymbol{\beta_9} \mathbf{CREDITAV} + \beta_{10} \mathbf{GROCEXP}_i + \beta_{11} \mathbf{NOFEMALE}_i + \beta_{12}\ \mathbf{EXTADVS}_i + \beta_{13} \mathbf{NLS}_i + \beta_{14} \mathbf{LANDSIZE} + \varepsilon_i$$

The maximum likelihood estimation [MLE] for extension and non-extension of the three crops was estimated and summarized in Table 13. The dependent variable in all cases is reported by technical inefficiency. For this study we employed the two-stage estimation by using the MLE (Arega et al, 2003). The estimation of inefficiency determinants using two stages is indeed controversial; a problem with the two-stage procedure is a lack of consistency in assumptions about the distribution of the inefficiencies. In the first stage, inefficiencies are assumed to be independently and identically distributed (iid) in order to estimate their values. However, in the second stage, estimated inefficiencies are assumed to be a function of a number of firm-specific factors, and hence are not identically distributed (Coelli, Rao & Battese, 1998). Kumbhakar et al (1991), Reifschneider et al (1991) estimated all of the parameters in one step to overcome this inconsistency. The inefficiency effects were defined as a function of the firm-specific factors (as in the two-stage approach), but were incorporated directly into the MLE

Table 13: Summary to the Determinants of Inefficiency in Maize, Teff, and Wheat

Variable	**Adopters**			**Non-extension farmers**		
	Maize	**Teff**	**Wheat**	**Maize**	**Teff**	**Wheat**
Education Dummy	√(-)					
Religion Dummy		√(+)				
Region dummy	√(-)	√(-)	√(-)	√(-)	√(-)	√(-)
Age	√(-)	√(+)				
SEX						
Distance from primary market				√(-)		
Number of female	√(-)		√(-)	√(+)	√♣(-)	
Grocery Expenditure	√(-)					
Number of livestock		√(-)				√(-)
Current selling Price		√(+)	√(+)	√(-)	√(+)	
Land size	√(+)	√(+)		√(+)		√ (-)
Household Size			√ (+)			
Total Factor Productivity	√(-)	√(-)		√(+)	√(+)	
Constant	√(+)				√(-)	

♣ Household size and number of female are substitutes in this case.

The summary table (Table-13) depicts that among other variables, agro-ecology/ regional dummy, average producer price, land size, total factor productivity, number of livestock and number of female in most of the cases determine the level of inefficiency. We expect there is a negative relationship between selling price and inefficiency. But it has positive relationship with inefficiency; most probably farmers producing at a level closer to the frontier sell at lower price than farmers producing at lower production frontier, which sell their output at higher price. This selling price here shows an effect relationship rather than cause. Second the income-leisure argument is also important to consider. Improved technology is profitable for both maize and teff, even if output prices decline by 25% or 50% (Howard et al, 1999), which shows the selling price, depends on the productivity of farmers assuming that more efficient farmers are more productive. However, the direction of influence of plot size on efficiency is mixed in general, as cases of many findings indicated; Kumbahakar et al (1999) and Alvarez &Arias (2004) show that large farms are relatively more efficient while Ahmed and Ureta (1995) found negative relationship for Spain diary farms. Huang and Kalirajan (1997) found that the size of household arable land is positively related to technical efficiency in maize, rice and wheat production in China. Parikh et al. (1995) find that cost inefficiency increases in farm size. Hazarika et al. (2003) have also shown that cost inefficiency in tobacco production is negatively related to tobacco plot size but unrelated to total farm size in Malawi. For Kenya, the estimation result for maize shows that larger maize plot sizes are more deficient (Liu, 2005), which is contrary to the finding in this study for Ethiopia.

In the case of the regional dummy, the coefficient is statistically significant at 1% level in all cases; indicating that as we move from north to south Ethiopia, inefficiency decreases. The education dummy in most of the cases has the expected negative sign even though is insignificant. This is very much consistent to the earlier findings in Ethiopia (Mulat et al 2003; Arega et al 2003; Beyene, 2004). Primary education indeed is not only the source of efficiency or a source of economic growth (Paulos & Mekonnen, 2004) but also the source of productivity. The finding in this study shows that in both extension and non-extension farmers as the number of female is increasing there is a sign of improvement in efficiency. This reveals that female labour have greater role to play in increasing farm efficiency

Rationally people expect that too much expenditure on recreation is a sign of inefficiency in livelihood. The finding in this study shows that grocery expenditure, as a measure of recreation does not as such influence farmer's inefficiency in Ethiopia. The variable is significant only in the case of extension maize farmers out of six cases. The case of maize is contrary to our expectation in that the rise in grocery expenditure is decreasing inefficiency. This is possibly due to the positive role of the expenditure on recreation in facilitating information and experience exchange among farmers, particularly when the expenditure lies within the economic and social norm of the society.

The total factor productivity indicating as one of the positive factors determining the level of efficiency of extension and non-extension farmers, as the finding depicts for all the two cereals (except wheat). This is consistent with the theory that factor productivity influences the level of efficiency of producers (Colelli & Batisse, 1998). In this connection it is worth important to note that agro-ecological factors related to soil and climate influences TFP and in turn the level of TFP influences the efficient utilization of factors of production.

There is a huge potential in Ethiopia to increase output by increasing total factor productivity through application of modern technology (as in extension farmers) and use of farm resources. This is clearly observed by the mean level of efficiency attained in maize, teff and wheat with 52%, 80% and 76% extension farmers respectively. There seems to be an efficiency gap ranging from 48% in maize to 24% in wheat, implying that farmers still can increase output by increasing efficient utilization of their inputs. On the same level, the non-extension farmers, attained mean efficiency of 84%, 83% and 63% for maize, teff, implying that they can increase output by increasing their efficiency on average by 16%, 17% and 37% respectively.

Conclusion and Recommendation

After the commencement of the extension program in 1995, the number of farmers using modern technology inputs increased considerably. This study, with and objective to assess the TFP and technical efficiency and the differences between farmers engaged in the extension package program and the non-extension farmers, presents the results based on sample farmers producing maize, teff and wheat from four regions. For the TFP comparison, we employed the *Tornquvist index*, which is found to be appropriate measurement for this kind of study. Under this index, the TFP estimation is based on the utilization of labour, fertilizer and draught power (oxen-timad-days) inputs. The estimated result shows that 65%, 65% and 96% of the sample extension farmers in maize, teff and wheat respectively have TFP greater than that of the non extension farmers, implying that on average TFP declines from extensions to non-extensions for the majority of sample households for all the three crops; and this is true for both matching and non-matching cases. It has an overall implication that the technologies in extension package have brought about substantial difference between extensions and non- extensions participating farmers. Based on the finding we detect that high TFP difference is observed in wheat, followed by maize and teff. The estimation from multiple regression analysis clearly indicated that, TFP differences other than the inputs show that age, distance from market, frequency of cultivation per hectare of land, plot size, labour and agroecological differences are significantly influencing the level of TFP. Fertilizer use is important determinant in case of extensions farmers. Number of male or female in the farm household, access to extension advises, price of output, quantity of seed, education and religion dummies do not seem to have consistent influences on the level of TFP. This kind of study is hardly conducted in Ethiopia and makes it difficult to compare with other finding. However, Based on this finding, we can safely conclude that technology packages of extension service on average have made some remarkable difference in productivity between extension and non-extension farmers.

Similarly, based on the data set, Technical efficiency was estimated for maize, teff and wheat extension and non-extension farmers. Econometric tests significantly rejected the trans-log production function in favor of Cobb-Douglas; and second, regarding the tests for using selecting half-normal against truncated-normal, the later is rejected.The estimated result shows that in terms of technical efficiency for the given samples, the maximum mean technical efficiency is observed in maize non-adopters while the minimum is observed in maize adopters households. The implication for maize producing households is that compared to the most technically efficient farmers, there are many technically inefficient farmers in the extension rather than in the case of non-extension maize farmers. Moreover, on average maize extension farmers can increase technically efficient utilization of inputs by about 48% as compared to only 16% in non-extensions. The technical efficiency in teff is higher for extensions i.e. 80% and almost equal to the case of non-adopters in maize that is 83%. On average, teff extension farmers can increase efficiency by about 20% while the non-extensions can increase by about 17%. At the other end the technical efficiency of wheat extension and non-extension farmers is about 76% and 63% respectively, implying that they can increase efficiency on average by about 24% and 37%. We see that teff and wheat extension farmers are more efficient than the non-extension farmers while this is contrary to the case of maize, where most of the extensions are less efficient. Behind these findings is that in stochastic frontier, all farmers are compared against the most efficient_farmer. The estimated technical efficiency shows there is vast potential in Ethiopia to increase output by increasing total factor productivity through application of modern technology and by allocating scarce resources- labor, draught power, and fertilizer

Mirroring the farm efficiency from performance perspectives, estimates of inefficiency model estimated result shows that the agro-ecology variable represented with regional dummy, price, land size, TFP, number of livestock and number of female in the household are found to be significantly influencing the technical inefficiency in most of the cases. Time and again, the coefficient of education dummy is negatively influencing technical inefficacy despite its insignificance. In one of the findings it came out clear that the importance of considering agro-ecological differences and there is an indication pattern that as we move from north to south Ethiopia, technical inefficiency declines consistently for all cases. It may be safely concluded from here on ward, the agro-ecologies play a significant role in influencing TFP and Technical efficiency due consideration should be given in agricultural technology targeting for agro-ecology. Smallholding as compared to large plot sizes can be efficient in countries of high rural population. There is ample potential yet to be tapped for both extension & non-extension farmers not only by improve efficiency in resource utilization but also by increasing total factor productivity through application of modern technologies. Finally, conducting similar studies further dealing with TFP and efficiency with wider sample size coverage might be formidable to bring about more dependable result informing on the coefficients of the determinants.

REFERENCE

Abate Bekele, Machel F. Viljoen and Gezahegn Ayele (2006): Effect of Farm Size on Technical Efficency of Teff Production: A case Study of the Moretina Jiru District, Central Ethiopia

Abebe Kirkos and Negussie Dejene (2005): The Ethiopian Agricultural Enumeration Sample In-depth Analysis Proceeding of a Workshop 6 June 2005: The Effect of Land Tenure, Fragmentation, Farm Size and Soil Conservation on Farm Productivity in Oromia, Central Statistical Authority, Addis Ababa

Arega Demelash, Rashid M. Hassen & Mulat Demeke (2003) The Technical, Allocative and Economic Efficiency of Maize Production under Improved Technology In the Bako Area of Western Oromia: A Stochastic Efficiency Decomposition Approach, Proceeding of the National Workshop on Technological Progress in Ethiopian Agriculture, Nov.29-30, 2001, Addis Ababa, Ethiopia

Assefa Admassie and Gezahegn Ayele (2004) Adoption of Improved Technology in Ethiopia

Beyene Tadesse (2004) The Impact of Policy Reform and Institutional Transformation on Agricultural Performance: An Economic Study of Ethiopian Agriculture, Development Economics & Policy, Hohenhiem University, Lang Publisher Germany

Colelli, T.J.(1995) "Recent Developments in Frontier Modeling and Efficiency Measurement Modeling," ***Australian Journal of Agricultural Economics***, 39 (3): 219-245

Colelli, T.J, and Batisse, G. (1996) "Identification of Factors Which Influence the Technical Inefficiency of Indian Farmers" ***Australian Journal of Agricultural Economics***, N0. V0l 40 (2): 103-128

Colelli, T.J, and Rao, Parasada D.S., Batisse, G. (1998). An Introduction to Efficincy and Productivity Analysis, Klewer Avcademic Publishers, Boston/Dordretch/London

Federal Democratic Republic of Ethiopia, Central Agricultural Census Commission (2004) Ethiopian Statistical Authority, Addis Ababa, Ethiopia

Gavian, S. and Ehui, S.(1996) The Relative Efficiency of Alternative land Tenure Contracts in a Mixed Crop Livestock System in Ethiopia, ILRI, Addis Ababa, Ethiopia

Gezahegn Ayele(2002). Conservation Tilling in Teff Production: Case of farmers around Debrezeit, EARO, Addis Ababa, Ethiopia

Gutema, Paulos and Bekele, Mekonnen (2004) "Does Schooling Contribute to the Economic Growth of Sub-Sahara African Countries", ***African Development Review***, N0.4 Vol 16

Hailemariom T/wold.; Gezahegn Ayele., Tekalign Mamo, Teklu Erkossa and Selamyhun (2006). Economic optimum of Fertilizer use for wheat production in Vertisol areas of central Ethiopia. **Ethiopian Journal of Agricultural Economics** Vol. 6 No. 1. 2006

Holden S., T., Benin, S., Shiferaw, B. and Pender, J. (2003) Non-farm Income, Household Welfare, and Sustainable Land Management in a Less favored Area in the

Ethiopian Highlands; Department of Economics and Resource Management, Agricultural University of Norway, Discussion Paper #D-06/2004

Howard, A. J, Kelly, V., Stepanek, j., Crawford, W. E., Mulat D., and Maredia, M. (1999) The Promise and Challenge of the Ministry of Agriculture/SG2000 Experiment With Improved Cereals Technology in Ethiopia, MSU International Development Working Papers No.76 Department of Economics, Michigan State University, USA

Khatri, Y., Leruth, L., Piesse1, J. (2002), Corporate Performance and Governance: A Stochastic Frontier Approach to Measuring and Explaining Inefficiency in the Malaysian Corporate Sector, Blackwell Publishers, Oxford

Kudaligama, V.P and Yanagida J.F (2000) A comparison of Inter-country Agricultural Production Functions: A Frontier Function Approach, Journal of Economic Development, 25:1

L_eopold Simar Paul W. Wilson (2005) Estimation and Inference in Cross-Sectional, Stochastic Frontier Models (web)

Liu, Yanyan (2005) Model Selection and Implications in Stochastic Frontier Analysis: Maize Production in Kenya, Department of Agricultural Economics and Department of Economics-Michigan State University, East Lansing, December 15, 2005

Mulat Demeke (1999) Agricultural Technology, Economic Viability and Poverty Alienation in Ethiopia, Department of Economics Addis Ababa University, Presented at Agricultural Transformation Policy Workshop, Nairobi, Kenya

Mulat Demeke and Bekele Hundie (2003) The Determinants of Yield of Major Cereals: The Contribution of New Technologies in Selected Villages of Ethiopia, Proceeding of the National Workshop on Technological Progress in Ethiopian Agriculture, Nov.29-30, 2001, Addis Ababa, Ethiopia

Mulat Demeke and Nigussie Tefera (2003) The Productivity & Profitability of Wheat and Teff Technologies Comparison Between Extension and Non-extension Plots in Three Selected Villages, Proceeding of the National Workshop on Technological Progress in Ethiopian Agriculture, Nov.29-30, 2001, Addis Ababa, Ethiopia

Stata reference guide ver. 8.2 2003: http://www.stata.com

Samia Zekaria and Habekristos Beyene (2005) The Ethiopian Agricultural Enumeration Sample In-depth Analysis, Proceeding of a Workshop 6 June 2005: Multivariate Discriminant Analysis: Participation in New Extension Package Program & Its Effect on Crop Productivity in Oromia Region, Central Statistical Authority, Addis Ababa

Tenkir B, Gezahegn A. and Tadesse K. (2004), Agricultural Extension, Adoption, Diffusion and Socio Economic Impact in the Four Regions [Tigray, Amhara, Oromia and SNNPR], Research report N0.1Addis Ababa, Ethiopia

Wadud, M.A. (2002) A Comparison of Method of Efficiency Measurement for Farms in Bangladesh, Department of Economics, University of Rajishash

Y. Khatri, L. Leruth and Piesse1, J (2002). Corporate Performance and Governance: A Stochastic Frontier Approach to Measuring and Explaining Inefficiency in the Malaysian Corporate Sector; IMF Working Paper No. 02/152