

THE IMPACT OF FARMER FIELD SCHOOL TRAINING ON FARMERS' TECHNICAL EFFICIENCY: EVIDENCE FROM SMALLHOLDER MAIZE FARMERS IN OROMIA, ETHIOPIA

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ABSTRACT: *This study examines the impact of Farmer Field School (FFS) training program on technical efficiency of smallholder farmers. The FFS program was sponsored by the Ethiopian government and launched in 2010 to scale-up best agricultural practices in the country. The study aims to compare changes in the technical efficiency of those FFS graduate and non-FFS graduate maize farmers in Ethiopia. For this, panel data were collected in two rounds from 446 randomly selected households from three districts consisting of 218 FFS graduate farmers and 228 non-FFS graduate farmers. The analytical procedure has involved three stages: in the first stage, descriptive analyses were used to detect existence of difference in the outcome indicators between the two farmer groups. In the second stage, a semi-parametric impact evaluation method of propensity score matching with several matching algorithms was employed to estimate the program impact. In the third stage, Difference-in-Difference was used as robustness check in detecting causality between program intervention and the technical efficiency changes. The Combined uses of these alternative estimation techniques indicate that the program has negative impact on the technical efficiency of the FFS graduates. Numerous plausible explanations for this outcome are discussed, and recommendations for improvements are suggested accordingly.*

KEYWORDS: Impact Evaluation, technical efficiency, propensity score matching, difference in difference

INTRODUCTION

The agricultural sector has always been an important component of the Ethiopian economy. During 2012/13, agriculture accounted for 42.7 percent of the gross national product (GDP), 80 percent of employment and over 70 percent of total national foreign exchange earnings. In contrast, industry and service sector accounted for 12.3 and 45 percent of GDP respectively during the same period (MoFED, 2014).

A unique feature of the Ethiopian agriculture is the role of smallholder farms in the total national output production and labour employment. For example, of the total production of 251 million quintals in 2012/13, about 96 percent (241 million quintal) was produced by the smallholder farmers and the rest 4 percent (10 million quintal) was produced by commercial farms. On the average, 83 percent of farmland in Ethiopia is held by small farmers with average size of a household landholding of 1.25 ha. These facts clearly denote that small farms are the main sources of the production and employment generation in Ethiopia. Evidences also suggest that small farms provide a more equitable distribution of income and an effective demand structure for other sectors of the economy (Bravo-Ureta and Evenson 1994).

The Ethiopian government has thus issued agricultural policy and investment framework (PIF). PIF provides a clear statement of the goal and development objectives of the country spanning the over ten years of 2010 to 2020. The development objective, as stated in the policy document, aims to sustainably increase rural incomes and national food security through increased production and productivity. To this end, farmer field school training is considered as the best strategy to scale up the best practices used by the model smallholder farmers whose productivity is more than two times higher than the average (FDRE, 2010).

The aim of FFS was to give special training to some purposively selected ‘model farmers,’ who, in turn, are supposed to transfer the knowledge to the rest through their farmers’ networks that are administratively organized. Accordingly, the selection of the ‘model farmers’ into the training program was made by the district level government officials in collaboration with the Kebele level (the lowest administrative unit in Ethiopia) development agents. Although there was no as such transparent criterion guiding the selections of the model farmers, the past performance of the farmers in terms of adoption of technological packages, agricultural production outputs, their location/geographic accessibility and educational level were mainly considered as selection criteria. Ultimately, those who were administratively sampled attended all the training sessions lasting for 15 days. There was a minimum of eight hours of training per day, making the total training hours 120. After the completion of the model farmers’ training, there were again series of meetings held with all farmers within each Kebele with the aim of briefing the essences of the training and how to organize all farmers into 1 to 5 network called “sub-development team” so as to facilitate the diffusion of knowledge and best practices from the FFS participants (FFS graduates) to non FFS participants. The desired outcome of FFS was to increase technology adoption and technical efficiency of the smallholder farmers as means to increase their production and productivity. In effect, policymakers have focused their attention on increasing the adoption of new technologies and improving their technical efficiency as means to increase smallholder farmers’ productivity and crop income.

However, the prices of new technologies are increasing in the face of capricious output prices and declining farm holding sizes which discourage technology adoptions. Furthermore, presence of possible technical inefficiency means that output can be increased without the need for new technology. If there appears significant inefficiency among the smallholder farmers, then, the agricultural policy should gear towards training them on how to increase their efficiency with the existing technology. This is because merely increasing the adoption of more expensive agricultural technology may result in liquidating the existing meager assets of the rural producers with very little productivity gain. This calls for increasing productivity and production through optimum and efficient use of the existing technologies (Bravo-Ureta and Pinheiro 1993). However, studies that systematically analyze the impacts of FFS on technical efficiency of the smallholder farmers are lacking. Therefore, this study aims to fill this knowledge gap. To this end, the paper aims to empirically examine the impact of FFS on the technical efficiency of FFS graduates in comparison with that of the non-FFS participants. We have employed two estimation methods: Propensity Score Matching (PSM) and Difference-in-Difference (DID). The former method helps to match program participating farmers and non-participating farmers based on their baseline similarities and clear out those factors to single out only program impacts. The latter approach (DID) help to difference out unobservable factors from the impact analysis process.

METHODS

Study area and sampling: This study was conducted in three purposively selected major maize producer districts in the Oromia region, East Wollega zone: Guto Gida, Gida Ayana and Boneya Boshe districts. These three districts were purposively selected from the zone on the basis of their land under maize production and the role that maize plays in their socio-economic developments. In these areas, cultivation of maize crop occupies an important place in the crop production plan of the farmers. For this study, maize crop is purposively selected because of the fact that it is Ethiopian's largest cereal commodity in terms of total production, productivity, and the number of its smallholder coverage (IFPRI, 2010).

Sample size: Following the procedures employed by IDB (2010) and World Bank (2007), we have employed power analysis for sample size determination. Accordingly, equal number of 246 smallholder farmers from both from FFS graduates and non FFS graduates thereby making total sample size of 492. However, to ensure that there will be non-FFS graduates with the same value of covariates as FFS graduates and hence to ensure the existence of common support region without which program impact estimate with the PSM is impossible, we wanted to sample larger samples size of the non-FFS graduates with respect to the FFS graduates. This is because it is expected that some non-FFS graduate farmers may be dropped from the sample in case their propensity score of covariates fail to match with the propensity scores of the FFS graduates thereby reducing the sample size as well as the size of common support region. Thus, our initial

sample size was 246 from the FFS graduates and 250 from the non-FFS graduate farmers thereby making total sample size of 496. Finally, completed data for the three years were collected from 218 FFS graduate and 228 non-FFS graduate farmers thereby making total sample size of 446.

Sampling strategy: First, we have selected three districts with good maize growing records. Second, from each district, we have purposively selected one kebele, from which households were randomly selected. Following the FFS program design, we have stratified our households from each Kebele into two excludable groups as: (i) FFS graduate farmers who were selected for the FFS training program, and; (ii), non-FFS graduate farmers who were exposed to the FFS training via the FFS graduates and hence supposed to follow their best practices. Finally, we made six sampling frame for the three kebeles since we have two strata in each kebele. Stratified probability-proportional-to-size sampling offers the possibility of greater accuracy by ensuring that the groups that are created by a stratifying criterion are represented in the same proportions as in the population (Bryman, 1988). Accordingly, we have divided the total samples of 496 across the Kebeles as well as between the FFS graduates and non-FFS graduates following probability-proportional-to-size sampling technique. However, although 496 questionnaires were distributed to the sampled households, we have collected 446 properly filled questionnaires with distribution across the selected study districts as 142, 160 and 144 from Guto Gida, Gida Ayana and Boneya Boshe districts respectively.

Data sources and collection techniques: Data collection was classified into two stages. In the first stage, qualitative data were collected using key informant interviews and focus group discussions. In the second stage, detailed quantitative data were collected using structured questionnaires prepared with full understanding of the nature of the program. The questionnaires were pre-tested and ensured that all included items were relevant and the questionnaire contained the correct format for the data collection. The survey was conducted in two rounds using the same questionnaire format, the same enumerators and during the same season of June to July in 2012 and 2013.

Estimation of Technical Efficiency: - Stochastic frontier production function is widely proposed efficiency measures for the analysis of farm-level data (Farrel, 1957; Battese, 1995; Bamlaku et al., 2009). Thus, we have used the technical efficiency model specified by (Battese and Coelli, 1995) which allows a stochastic frontier production function for panel data with farmer effects that can vary systematically over time and are assumed to be distributed as truncated normal random variables. The model can be specified as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \quad i=1,2,\dots,N, \quad t=1,2,\dots,T \dots\dots(1)$$

Where, Y_{it} is the logarithm of the production of the i -th household in the t -th time period, X_{it} is vector of values of known functions of inputs of production and other explanatory variables associated with the i -th firm at the t -th observation; and β is a vector of unknown parameters. Here, the error term comprises two separate parts, V_{it} are random variables outside the control of the households which affects the productivity of the households and assumed to be identically and independently distributed (iid) $N(0, \sigma_v^2)$ and independent from U_{it} ; U_{it} represents factors contributing towards technical inefficiency but which are supposed to be within the control of the households.

The measure of technical efficiency is equivalent to the ratio of the production of the i -th household in the t -th time period to the corresponding production value of the frontier household whose U_i is zero. Thus, it follows that given the specifications of the stochastic frontier production function defined by equation (1), the technical efficiency of the i -th household in the t -th time period can be defined by:

$$TE_{it} = (X_{it}\beta + v_{it} - U_{it}) / (X_{it}\beta + v_{it}) = (X_{it}\beta - U_{it}) / (X_{it}\beta) = -U_{it} \dots (2)$$

Where U_{it} and $X_{it}\beta$ are defined by the specifications of the model in equation (1). In this study, Cobb-Douglas stochastic frontier production function, which is the most commonly used model, is considered to be the appropriate model for the analysis of the technical efficiency of the farmers. On the basis of panel data, equation (1) above can be expressed in the following form:

$$Y_{it} = A L_{it}^{\beta_L} K_{it}^{\beta_K} e^{V_{it}} e^{-U_{it}} \dots (3) \quad \text{Where } V_{it} \text{ follows}$$

$N(0, \sigma_v^2)$ and U_{it} follows a half or truncated normal distribution at zero. Taking natural log on both sides of equation (3), the following equation is obtained:

$$\ln Y_{it} = \ln A + \beta_L \ln L_{it} + \beta_K \ln K_{it} + (V_{it} - U_{it}) \dots (4)$$

Finally, the following equation was estimated by the computer programme FRONTIER 4.1 developed by Coelli (1994) that computes the parameters estimates by iteratively maximizing a nonlinear function of the unknown parameters in the model subject to the constraints.

$$\ln(Y_{it}) = \beta_0 + \beta_{1it} \ln X_{1it} + \beta_{2it} \ln X_{2it} + \beta_{3it} X_{3it} + \beta_{4it} \ln X_{4it} + \beta_{5it} X_{5it} + \beta_{6it} X_{6it} + \beta_{7it} X_{7it} + \beta_{8it} X_{8it} + V_{it} - U_{it} \dots (5)$$

Where, β_i 's are parameters to be estimated (coefficients) of inputs to be estimated by maximum likelihood estimation method (MLE). Here, the β_i 's refer to output elasticity. Ln is natural

logarithm, Y_{it} is denotes the production in (kg) at the t -th observation ($t = 1, 2, \dots, T$) for the i -th farmer ($i = 1, 2, \dots, N$); X_{1it} is maize farm size (ha), X_{2it} is human labor (man-days), X_{3it} is oxen labour used (oxen-days), X_{4it} is DAP fertilizer used (kg), X_{5it} is urea fertilizer used (kg), X_{6it} is improved seed used (kg), X_{7it} is compost used (quintal), X_{8it} represents year of observation; v are assumed to be iid $N(0, \delta_v^2)$ random errors, independently distributed of the μ_{it} s, U_{it} represents technical inefficiency effects independent of V_i , and have half normal distribution with mean zero and constant variance while i shows households during the time t year. Battese and Coelli, (1995) noted that the *year* variable in the stochastic frontier accounts for Hicksian neutral technological change.

Following Battese and Coelli (1995) model, the mean of farm-specific technical inefficiency U_i , is also defined as:

$$u_{it} = \delta_0 + \delta_{1it}Z_{1it} + \delta_{2it}Z_{2it} + \delta_{3it}Z_{3it} + \delta_{4it}Z_{4it} + \delta_{5it}Z_{5it} + \delta_{6it}Z_{6it} + \delta_{7it}Z_{7it} + \delta_{8it}Z_{8it} + \delta_{9it}Z_{9it} + \delta_{10it}Z_{10it} + \delta_{11it}Z_{11it} + \delta_{12it}Z_{12it} + \delta_{13it}Z_{13it} + \delta_{14it}Z_{14it} + \delta_{15it}Z_{15it} + \delta_{16it}Z_{16it} + \delta_{17it}Z_{17it} + W_{it} \dots (6)$$

Where Z_1 is age of the farmers (years) during the year, Z_2 is gender of household head [1 male, 0 otherwise], Z_3 is marital status of household [1 married, 0 otherwise], Z_4 represents that the household head can read and write [1 yes, 0 otherwise], Z_5 is educational level of household head (years of schooling), Z_6 farming experience of household head (years), Z_7 is family size, Z_8 is average annual non farm income (Birr), Z_9 is household head has radio [1 yes, 0 otherwise], Z_{10} shows that the household has land use certificate [1, yes; 0 otherwise], Z_{11} is total land size of the household (hectare), Z_{12} is distance of household residence from the technology distribution center (hours), Z_{13} is average annual development agents visit to the house hold (number), Z_{14} is plough frequency of maize land (number), Z_{15} represents Guto Gida district [1 Guto Gida, 0 otherwise], Z_{16} represents Gida Ayana district [1 Gida Ayana, 0 otherwise], Z_{17} represents year of observations, W_{it} , is defined by the truncation of the normal distribution with zero mean and variance, δ^2 , and δ_s are parameters to be estimated. Here, the *year* variable in the inefficiency model (6) specifies that the inefficiency effects may change linearly with respect to time. This is because “the distributional assumptions on the inefficiency effects permit the effects of technical change and time-varying behavior of the inefficiency effects to be identified in addition to the intercept parameters, β_0 and δ_0 , in the stochastic frontier and the inefficiency model” (Battese and Coelli, 1995).

Analytical Approach: The main challenge of this study, as it is the case for other impact evaluation studies, is to decide on the correct counterfactual: *what would have happened to the*

level of technical efficiency of those farmers who participated in the training program if the program had not existed? Given the non-random selection of farmers for the program participation, estimating the outcome variables by using the OLS would yield biased and inconsistent estimate of the program impact due to some confounding factors: purposive program placement, self-selection into the program, and diffusion of knowledge among the program participant and non-participant farmers. Thus, our impact evaluation design should enable us to control for such possible biases.

For this, we have employed two impact assessment methods: Propensity Score Matching (PSM) and Difference-in-Difference (DID). The former method helps to match program participating farmers and non-participating farmers based on their baseline similarities and clear out those factors to single out only program impacts while the latter approach (DID) helps to difference out unobservable factors from the impact analysis process. The combined use of these alternative estimation techniques is expected to lead to consistent results.

Propensity score matching (PSM): In the absence of random selections, those farmers who participated in the FFS training and those excluded from it may differ not only in their participation status but also in other characteristics that affect both participation, agricultural productivity and technical efficiency of the farmers. The Propensity Score Matching (PSM) seeks to find non-participating farmers among farmers not receiving the training that are similar to the participating farmers, but did not participate in the training program. PSM does this by matching participating farmers to non-participated farmers using propensity scores. In other words, this approach tries to replicate the training selection process as long as the selection is based on observable factors (Essama-Nssah, 2006; Ravallion, 2008; World Bank 2010; IDB, 2010). Thus, PSM searches a group of “control” farmers who are statistically “similar” in all observed characteristics to those who participated in the training program.

Under certain assumptions, matching on Propensity Score, $P(X)$, is as good as matching on X . Therefore, rather than attempting to match on all values of the variables, cases can be compared on the basis of propensity scores alone, given that all observable variables which influences program participation and outcome of interest are properly identified and included (for further explanations on PSM, please see, Essama-Nssah, 2006; Heinrich et al., 2010; World Bank, 2010).

PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment T conditional on observed characteristics X , or the propensity score is given by:

$$P(x) = pr(T = 1 | x) \dots \dots \dots (7)$$

The propensity score or conditional probability of participation may be calculated by using a probit or a logit model in which the dependent variable is a dummy variable T equal to one if the farmer participated in the FFS training and zero otherwise (Ravallion, 2008; World Bank, 2010; IDB, 2010). Although the results are similar to what would have been obtained by using probit, we have used logit model to estimate participation equation in this thesis.

However, in order to determine if matching is likely to effectively reduce selection bias, it is crucial to understand the two underlying assumptions under which the PSM is most likely to work: *Conditional Independence Assumption* and *Common Support Assumption*.

Conditional Independence Assumption: states that given a set of observable covariates X which are not affected by the program intervention; potential outcomes are independent of treatment assignment. If Y_1 represents outcomes for participants and Y_0 outcomes for non-participants, conditional independence imply:

$$(Y_1, Y_0) \perp T_i | X_i \dots \dots \dots (8)$$

This implies that selection is solely based on observable characteristics and that all variables that influence treatment assignment and potential outcomes are simultaneously observed by the researcher. Put in other words, it is to mean that after controlling for X , the participation assignment is “as good as random” and participation in the FFS training program is not affected by the outcomes of interest (Imbens, 2004; Ravallion, 2008; World Bank, 2010; IDB, 2010). This allows the non-participating households to be used to construct a counterfactual for the participating group. This assumption is sometimes called exogeneity or unconfoundedness assumption or ignorable treatment assignment (Imbens, 2004).

Clearly, this is a strong assumption since it implies that uptake of the program is based entirely on observed characteristics, and hence has to be justified by the nature of the program and data quality at hand. Although the nature of the program enabled us to justify that its uptake is based mainly on observable characteristics, we may relax such un confoundedness assumption since we are interested in the mean impact of the program for the participants only (Imbens, 2004; Essama-Nssah, 2006; Ravallion, 2008; World Bank, 2010).

$$Y_0 \perp T_i | X_i \dots \dots \dots (9)$$

This equation states that, the outcome in the counterfactual state is independent of participation, given the observable characteristics. Thus, once controlled for the observables, outcomes for the non-participant represent what the participants would have experienced had they not participated in the program.

Common Support Assumption: states that for matching to be feasible, there must be individuals in the comparison group with the same value of covariates as the participants of interest. It requires an overlap in the distributions of the covariates between participants and non-participant comparison groups. This assumption is expressed as:

$$0 < \Pr(T = 1|x) < 1 \dots \dots \dots (10)$$

This equation implies that the probability of receiving FFS training for each value of X lies between 0 and 1. It ensures that persons with the same X values have a positive probability of being both participants and non-participants (Heckman, Ichimura and Todd 1998; Imbens, 2004; Ravallion, 2008). More strongly, it implies the necessity of existence of a non-participant analogue for each participant household and existence of a participant household for each non-participant household. However, since we are interested in estimating the mean effect of the intervention for the participants, as opposed to the mean effect for the entire population, we will use a weaker version of the overlap assumption which is expressed as:

$$P(x) = \Pr(T = 1|x) < 1 \dots \dots \dots (11)$$

This equation implies the possible existence of a non-participant analogue for each participant. It would be impossible to find matches for a fraction of program participants if this condition is not met. Thus, it is recommended to restrict matching and hence the estimation of the program effect on the region of common support. This implies using only non-participants whose propensity scores overlap with those of the participants. In sum, participating farmers will therefore have to be “similar” to non-participating farmers in terms of observed characteristics unaffected by participation; thus, some non-participating farmers may have to be dropped to ensure comparability (Heckman, Ichimura, and Todd, 1998; Ravallion, 2008).

The main purpose of the propensity score estimation is to balance the observed distributions of covariates across two farmer groups (FFS graduates vs. non-FFS graduates) farmers. Hence, we need to ascertain that (1) there is sufficient common support region (overlapping of the estimated propensity scores) for the two groups of farmers, and; (2) the differences in the covariates in the matched two groups have been eliminated. These two issues are the necessary conditions for the reliability of the subsequent estimate of the program impacts. Although there are many methods of covariate balancing tests, literatures show that the standardized tests of mean differences is the most commonly applied method. Hence, we have employed two methods for this thesis: standardized tests of mean differences and testing for the joint equality of covariate means between groups using the Hotelling test or F -test. The following equation shows the formula used to calculate standardized tests of mean differences (Imbens, 2004).

$$B_{before}(x) = 100 \cdot \frac{\bar{X}_T - \bar{X}_C}{\sqrt{\frac{V_T(x) + V_C(x)}{2}}}, B_{after}(x) = 100 \cdot \frac{\bar{X}_{TM} - \bar{X}_{CM}}{\sqrt{\frac{V_T(x) + V_C(x)}{2}}} \dots (12)$$

Where for each covariate, \bar{X}_T and \bar{X}_C are the sample means for the full treatment and comparison groups, \bar{X}_{TM} and \bar{X}_{CM} are the sample means for the matched treatment and comparison groups, and $VT_{(x)}$ and $VC_{(x)}$ are the corresponding sample variances. Rosenbaum and Rubin (1985) suggest that a standardized mean difference of greater than 20 percent should be considered as “large” and a suggestion that the matching process has failed. In addition to test of covariate balancing, we have also checked that there is sufficient overlap in the estimated propensity scores of the two groups of farmers after matching.

Given that the above specified assumptions holds, and there is a sizable overlap in $P(X)$ across participants and non-participants, the PSM estimator for the average program effect on the treated (ATT) can be specified as the mean difference in Y over the common support, weighting the comparison units by the propensity score distribution of participants (Caliendo and Kopeinig, 2005; World Bank, 2010). A typical cross-section estimator can be specified as follows:

$$ATT_{PSM} = E_{p(x)|T=1} \{ E[Y_1|T=1, p(x)] - E[Y_0|T=0, p(x)] \} \dots\dots\dots(13)$$

This equation shows that, PSM estimator is simply the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

Difference in Difference (DID): Unlike the propensity score matching, DID assume that program participation is influenced by unobserved household heterogeneity and that such factors are time invariant. Having data collected for both before and after the program on both farmer groups, the unobservable time invariant component can be differenced out by using DID. Accordingly, this section assesses the impact of FFS program on technical efficiency of the farmers using DID.

With a two-period panel data set, impact evaluation using DID method can be estimated just by pooling the two periods’ data and use OLS to estimate the performance parameters (Feder, et al., 2004; Lifeng, 2010; World Bank, 2010). To specify the equation, assume that a farmer i lives in village j at a time t reporting performance of y , while x and z representing the household and village characteristics that changes over time.

$$\ln Y_{ijt} = \alpha_0 + \alpha D_t + \beta FFS_{ijt} + \mu x_{ijt} \gamma z_{ijt} + \lambda_i + \eta_j + \varepsilon_{ijt} \dots\dots\dots(14)$$

Where, D_t is dummy variable for the second year after the FFS program, FFS showing dummy variable (one if the household is FFS graduate and zero otherwise), λ_i and η_j representing unobserved, time constant factors influencing program participation in household and village respectively while ε_{ijt} showing idiosyncratic error representing the unobservable factors that changes over time. However, given the non random selections of the farmers into the FFS training program, just the naïve estimation of the program impact using OLS may yield

biased estimates for the reason that λ_i and η_j may be correlated with some of the explanatory variables thereby violating one of the fundamental assumptions of OLS. Thus, by subtracting the first period observations from the second period observations, equation 8 above can be condensed as:

$$\Delta \ln Y_{ijt} = \alpha + \beta FFS_{ijt} + \mu \Delta X_{ijt} \gamma \Delta z_{ijt} + \varepsilon_{ijt} \dots\dots\dots(15)$$

The symbol (Δ) in equation 15 above shows the differencing operator between the two periods, while both λ_i and η_j were eliminated by differencing. The dummy variable for the year of observation is also eliminated after differencing. Thus, α measures the before FFS training growth rate in performance for all farmer groups, while β measures the difference in growth rate between the FFS graduates and non FFS graduates after the FFS training program. Note that DID estimator provides unbiased FFS effects under the identifying assumption that change in outcome variable, y , for all groups of farmers would have been the same in the absence of the program although the level of y in any given year may differ (Feder, et al., 2004; World Bank, 2010). Thus, the quality of the DID estimator is that the differencing enabled us to control for the initial conditions that may have a separate influence on the subsequent changes in outcome or assignment to the treatment. As the result, any variations in performance owing to such factors (systemic climate change, price and other policy changes) that affect all farmers are eliminated and hence the individual coefficients in the model actually measure the contributions of each explanatory variable to the growth of the performance indicators.

RESULTS AND DISCUSSION

This section presents the survey results and discussions by dividing it into sections. In the first section, comparison of some selected household characteristics and maize production parameters for the baseline year is made by farmer groups so as to verify the similarities of the samples. Section two presents comparison of major input and output performance indicators between the FFS graduates and non-FFS graduate farmers before the implementation of the program. Section three presents comparisons of performance indicators before and after the program implementation. Section four then presents impacts of FFS employing PSM method, while section five extends the impact assessment using DID method.

Household and farm characteristics by farmer groups

Table 3.1 presents the descriptive statistics for both FFS graduates and non-FFS graduate farmers. Almost in all the cases, FFS graduates had the highest scores in terms of educational levels, non-farm income, family sizes, estimates of asset values, total land size as well as percent

of farm size covered by maize. Significant differences were also observed in the proportions of household owning mobile cell phone, radio ownership, participation in farmers training center, participation in farmers cooperatives, as well as in the number of contacts with the Kebele level development agent as those FFS graduate farmers had the highest scores than those non-FFS graduate farmers in all cases. In a sharp contrast with the FFS graduate farmers, non-FFS farmers are very far from such important locations as centers for farm technology distributions and from their respective district offices.

Table 3. 1: Household and farm characteristics during 2010 (by farmer groups)

| Variables | Mean | | t-test | |
|--------------------------------|--------------|------------------|--------------|--------------|
| | FFS graduate | Non-FFS Graduate | t | p> t |
| Household head age | 37.651 | 38.776 | -1.220 | 0.222 |
| Household head sex | 0.92661 | 0.87719 | 1.750 | 0.081 |
| Education level of head | 3.211 | 1.3684 | 6.940 | 0.000 |
| Household head literate | 0.72018 | 0.36842 | 7.950 | 0.000 |
| Farming Experience of head | 20.472 | 21.395 | -1.010 | 0.315 |
| None farm income | 1276.6 | 824.12 | 1.720 | 0.087 |
| Family size | 5.7569 | 5.2895 | 2.180 | 0.030 |
| Distance from techno center | 0.71353 | 0.76096 | -0.720 | 0.473 |
| Distance from district town | 6.8145 | 7.1766 | -0.800 | 0.422 |
| Have a pair of oxen | 0.73394 | 0.65789 | 1.750 | 0.082 |
| Have mobile cell phone | 0.33028 | 0.2193 | 2.640 | 0.009 |
| Have a radio (yes=1) | 0.46789 | 0.39035 | 1.660 | 0.099 |
| Estimated asset value | 18149 | 13479 | 2.040 | 0.042 |
| Household land size (Ha) | 2.0753 | 1.6758 | 2.710 | 0.007 |
| Have land use certificate | 0.83871 | 0.78947 | 1.330 | 0.183 |
| Head is member of cooperative | 0.84862 | 0.69737 | 3.860 | 0.000 |
| Head received FTC training | 0.36697 | 0.30263 | 1.440 | 0.151 |
| Number of DA contact/year | 9.5826 | 6.5965 | 2.470 | 0.014 |
| Oxen labour (Oxen day/Ha) | 13.528 | 10.43 | 3.680 | 0.000 |
| Total maize farm (Ha) | 1.4463 | 1.1012 | 3.620 | 0.000 |
| Percent of maize land to total | 86.4000 | | | 0.691 |
| | 89.600 | | 0.398 | |

Source: Own calculation from survey data of June to July, 2012.

Such significant difference between the farmers groups was not just the result of non-random selection of the farmers into the FFS training program. Rather, it was the result of the intended

principles of selection criteria followed by the government. As the result, although there was no as such transparent criterion guiding the selections of the model farmers, the educational level of the farmers, the past performance of the farmers with adoption of technological packages, agricultural production outputs, accessibility of farmers in terms of geographical location and history of participation in farmers training centers were some of the factors considered in selecting the participant farmers.

Cost and Returns of Maize Production by Farmer Groups

Table 3.2 presents cost and returns of maize production by farmers' groups. Comparison of costs and returns between the two farmers groups shows that FFS graduate farmers were significantly different from their counterpart non-FFS graduate farmers specifically in terms of total maize obtained, technical efficiency, as well as in income from maize production measured both in terms of accounting and economic profits. However, the difference between the two farmer groups diminishes as we compare their productivity in terms of total maize per hectare; income from maize production measured both in terms of accounting and economic profits per hectare.

Table 3. 2: Costs and returns of maize production before the FFS training

| Variable | Mean | | t-test | |
|------------------------------|--------------|------------------|---------------|---------------|
| | FFS Graduate | Non FFS Graduate | t | p> t |
| Total maize (kg) | 6323.3 | 4550.7 | 3.590 | 0.000 |
| Maize yield (kg/ha) | 4048.147 | 3737.4 | 1.7977 | 0.0729 |
| Technical Efficiency (index) | 0.6176 | 0.5676 | 2.1280 | 0.0339 |
| Accounting income(Br) | 9795.7 | 6753.4 | 3.810 | 0.000 |
| Accounting income/ha | 6870.7 | 6241.5 | 1.670 | 0.096 |
| Economic income | 7972.3 | 5262.8 | 3.600 | 0.000 |
| Economic income/ha | 5422.2 | 4748.7 | 1.890 | 0.060 |
| DAP/ha (kg) | 78.893 | 80.401 | -0.450 | 0.656 |
| UREA/ha (kg) | 80.547 | 80.401 | 0.040 | 0.967 |
| Total cost/ha | 3807.1 | 3693.7 | 0.820 | 0.412 |
| Total labor/ha | 55.794 | 56.047 | -0.110 | 0.912 |
| Cash cost/ha | 2358.7 | 2200.9 | 1.360 | 0.174 |
| Non cash cost/ha | 1448.5 | 1492.9 | -0.620 | 0.537 |
| Family labor/ha | 46.635 | 48.329 | -0.680 | 0.496 |

Source: Own calculation from survey data of June to July, 2012.

Given the fact that FFS graduate farmers own larger farm size than those non-FFS graduate farmers, profit margin diminishes as we look at their profit per hectare. There was no as such apparent difference between the two farmer groups in terms of fertilizer use per hectare, total labor application per hectare and total cost per hectare.

Performance indicators by farmer groups

Table 3.3 presents comparisons of various input and output performance indicators between the two farmer groups before and after the FFS program intervention.

| Measurement year | 2010= y0 | | 2012 = y2 | | Difference = y2-y0 | |
|---------------------------------|---------------------|----------|----------------------|----------|----------------------|----------|
| Parameters | mean | Std. Err | mean | Std. Err | mean | Std. Err |
| Maize yield/ha in kg: | | | | | | |
| Non FFS Graduates | 3737.40 | 121.8 | 4042.74 | 132.91 | 305.344 | 121.86 |
| | 2 | 8 | 7 | | 7 | |
| FFS graduates | 4048.14 | 122.4 | 4138.46 | 124.7 | 90.3172 | 89.6580 |
| | 7 | 8 | 4 | | 8 | |
| t-test | -1.798* | | -0.524 ^{ns} | | 1.41 ^{ns} | |
| Labor yield(kg/man-day): | | | | | | |
| Non FFS Graduates | 68.609 | 2.678 | 68.507 | 2.496 | -0.103 | 2.319 |
| FFS graduates | 80.050 | 3.344 | 82.533 | 3.696 | 2.483 | 2.597 |
| t-test | -2.68*** | | - | | -0.744 ^{ns} | |
| | | | 3.1698* | | | |
| | | | ** | | | |
| Technical efficiency: | | | | | | |
| Non FFS Graduates | 0.57 | 0.02 | 0.58 | 0.02 | 0.01 | .0142 |
| FFS graduates | 0.62 | 0.02 | 0.61 | 0.02 | -0.01 | .0088 |
| t-test | -2.13** | | -1.60* | | 0.7571 ^{ns} | |
| Non cash cost/ha: | | | | | | |
| Non FFS Graduates | 1492.86 | 51.14 | 2596.64 | 98.682 | 1103.78 | 71.870 |
| | 3 | 5 | 6 | | 3 | |
| FFS graduates | 1448.45 | 50.28 | 2373.33 | 83.831 | 924.874 | 48.772 |
| | 7 | 8 | 1 | | | |
| t-test | 0.619 ^{ns} | | 1.718* | | 2.042** | |
| Family labor/ha: | | | | | | |
| Non FFS Graduates | 48.329 | 1.778 | 51.433 | 1.902 | 3.104 | 1.3096 |
| FFS graduates | 46.635 | 1.735 | 45.964 | 1.648 | -0.670 | .901422 |
| t-test | 0.681 ^{ns} | | 2.165** | | 2.354** | |
| Act income/ha: | | | | | | |
| Non FFS Graduates | 6241.53 | 264.0 | 11149.0 | 484.68 | 4907.50 | 404.26 |
| | | 69 | | | | |
| FFS graduates | 6870.68 | 268.8 | 11506.8 | 441.374 | 4636.18 | 315.116 |
| | 6 | 68 | 7 | | 4 | |
| t-test | - | | -0.544 | | 0.526 ^{ns} | |

| | | | | | | |
|-------------------|--------------|-------------|--------------|---------|--------------|---------------------|
| | 1.6693 * | | ns | | | |
| Econ income/ha: | | | | | | |
| Non FFS Graduates | 4748.66 4 | 248.5 52 | 8552.38 2 | 439.456 | 3803.71 8 | 372.785 |
| FFS graduates | 5422.22 9 | 255.8 56 | 9133.54 4 | 410.606 | 3711.31 5 | 303.522 |
| t-test | -1.889* | | -0.964 ns | | | 0.191 ^{ns} |

Note: *** Significant at 1%, ** significant at 5% and * Significant at 10%, ns non-significant difference.

Source: Own calculation from survey data

A statistical comparison in Table 3.3 reveals that the increase in productivity achieved by the non-FFS graduate farmers is found to be almost three times the increase in the productivity of FFS graduate farmers between the two time periods. Although the FFS graduates had statistically higher maize productivity before the training year [$t=1.798$], the difference gradually diminished two years after the training.

Vertical comparison reveals that FFS graduate farmers have maintained statistically significant labour yield both before and after the program implementation. However, comparison in terms of change in labour productivity between the two time periods reveals that the difference actually disappeared. Similarly, although FFS graduate farmers had statistically significant higher difference in terms of technical efficiency before the program implementation, this difference rapidly diminished two years after the program implementation. As a result, we couldn't find any statistical difference in terms of technical efficiency change between the two farmers groups over time period.

In addition, our analysis shows that the FFS graduate farmers have used more fertilizer per hectare and hence incurred more cash cost of production than those of non-FFS graduate farmers while the latter incurred significantly [$t=2.0419$] higher non-cash cost of production such as family labor, oxen and compost. Furthermore, the higher labour productivity difference in the face of lower productivity difference for the FFS graduate farmers also suggests less labour employment per hectare while the non-FFS graduate farmers increased the use of such input each year.

After two years of the FFS training, crop income of the non-FFS graduate farmers both in terms of accounting and economic profits has matched with that of the FFS graduated farmers, although the latter had significantly higher net crop income during the baseline year, 2010. The

consequence of FFS on technical efficiency is further investigated below employing more rigorous technique in the following section.

Assessment of Farmer Field School Impact Using PSM

PSM was employed to identify Although there are a number of methods to match the sample FFS program participants with the sampled non-FFS program households, the methods used in this analysis are the nearest neighbor matching (attnd), radius matching with two different calipers (attr 0.01 and attr 0.005) and kernel matching (attk), each with two different commands - *Psmatch2*ⁱ and *Pscore*ⁱⁱ.

Asymptotically, all the four matching methods with two different command types are supposed to lead to the same conclusion although the specific results may not be necessarily the same. This is to mean that, if the FFS impact on any of the impact indicator is robust, findings from most matching algorithms must lead to the same conclusion. Thus, such use of different matching algorithms with two different command types is used as effective method of checking the robustness of the estimation of program impact, which is again, to be confirmed by the impact assessment using DID in the subsequent section 3.5.

Estimation of the Propensity Scores

In estimating propensity score matching, the samples of program participants and non-participants were pooled, and then participation equation was estimated on all the observed covariates X in the data that are likely to determine participation (World Bank, 2010). In estimating the propensity scores, we first tried fitting all data collected on the covariates into logit model and gradually reduced the number of the covariates until we get the desired good match. Finally, we have maintained those influential covariates determining the program participation. The covariates included comprise of different forms of assets such as natural resource (land), financial resource (access to credit), physical asset (infrastructure such as access to roads), social capital (social networks), and human forms of capital (experience and education levels). Table 3.4 presents the logit estimates of the FFS program participation equation.

Table 3. 4: Estimation of Propensity Score: Dependent variable HH participation in FFS

| Variables | Coef. | Robust St.Err. | z | P> z | [95%Conf.interval] | |
|-----------------------|-----------|----------------|-------|------|--------------------|----------|
| Household head age | -.0108551 | .026434 | -0.41 | 0.68 | -.0626648 | .0409546 |
| Household head sex (1 | .0938002 | .392180 | 0.24 | 0.81 | -.6748586 | .862459 |

Log pseudolikelihood = -190.04376

Number of obs =445
Wald chi2(20)=74.71
Prob > chi2= 0.0000
Pseudo R² = 0.1549

| | | | | | | |
|--------------------------------|-----------|---------|------|------|-----------|-----------|
| male) | | 1 | | 1 | | |
| Household education | .0955047 | .069725 | 1.37 | 0.17 | -.0411551 | .2321646 |
| | | 7 | | 1 | | |
| Household literacy (1 yes) | 1.139841 | .375086 | 3.04 | 0.00 | .4046854 | 1.874997 |
| | | 3 | | 2 | | |
| Farming Experience | .0138987 | .025946 | 0.54 | 0.59 | -.0369545 | .064752 |
| | | | | 2 | | |
| None farm income (Birr) | .0000365 | .000043 | 0.83 | 0.40 | -.0000492 | .0001223 |
| | | 8 | | 4 | | |
| Family Size | -.0275738 | .063143 | - | 0.66 | -.1513332 | .0961857 |
| | | 7 | 0.44 | 2 | | |
| Distance from techno centre | -.0086456 | .128585 | - | 0.94 | -.2606677 | .2433766 |
| | | 1 | 0.07 | 6 | | |
| Distance from district town | -.0675697 | .039337 | - | 0.08 | -.1446702 | .0095308 |
| | | 7 | 1.72 | 6 | | |
| Has of a pair of oxen | .6056229 | .297372 | 2.04 | 0.04 | .0227828 | 1.188463 |
| | | 8 | | 2 | | |
| Has mobile phone | .2386495 | .286769 | 0.83 | 0.40 | -.3234074 | .8007064 |
| | | | | 5 | | |
| Estimated asset value | 7.35e-06 | .000010 | 0.71 | 0.47 | -.000013 | .0000277 |
| | | 4 | | 9 | | |
| Has land use certificate | .0971948 | .345000 | 0.28 | 0.77 | -.5789941 | .7733838 |
| | | 7 | | 8 | | |
| Head is member of coop. | .453459 | .324043 | 1.40 | 0.16 | -.1816549 | 1.088573 |
| | | 8 | | 2 | | |
| Number of DA visit/year | .017125 | .010149 | 1.69 | 0.09 | -.0027674 | .0370178 |
| | | 5 | | 2 | | |
| Head has access to credit | -.524440 | .375772 | - | 0.16 | -1.260941 | .2120588 |
| | | 1 | 1.40 | 3 | | |
| Household land size (ha) | .042385 | .104264 | 0.41 | 0.68 | -.1619685 | .2467394 |
| | | 1 | | 4 | | |
| Maize farm land (ha) | .198122 | .192552 | 1.03 | 0.30 | -.1792743 | .5755184 |
| | | 7 | | 4 | | |
| Constant | -2.9335 | .730499 | - | 0.00 | -4.365277 | -1.501771 |
| | | 6 | 4.02 | 0 | | |

Source: Own calculation from survey data of June to July 2010

It shows that some covariates are statistically significantly associated with FFS program participation. Educational level of the household head measured in terms of years of schooling, household head literacy measured as ability to read and write, possession of household assets such as one or more pair of farming oxen, mobile phone, total asset values, as well as social network such as participation in farmers cooperative, number of development agents' contact

with the household per year, possession of land use certificate, possession of larger farm size were positively associated with FFS program participation. In the contrary, such covariates as age of the household head, family size, distance from centers where farm technologies were distributed and distance from the district town were negatively associated with the FFS program participation. The younger the household head, the more likely she/he is better educated and hence has more chance of selection into the training program. These findings are consistent with the stated criteria of selecting household heads for FFS program participation as it was designed to train few affluent households, who are supposed to be easily trained and train others. These findings also indicate that participation in the FFS program was mainly influenced by observable covariates and hence hidden covariates played very little role which, in turn, implies that the results of program assessment using PSM approach were unbiased and consistent.

As the main purpose of the propensity score estimation was to balance the observed distributions of covariates across two farmer groups, we need to ascertain that there is sufficient common support region for the two groups of farmers. We also need to be sure of that the differences in the covariates in the matched two groups have been eliminated. These two issues are the necessary preconditions for the reliability of the subsequent estimations of the program impacts. The predicted propensity scores range from 0.0365417 to 0.8797614 with mean value of 0.3310722 for the FFS graduates farmers, while it ranges from 0.0185319 to 0.9011666 with mean value of 0.1716005 for those non-FFS graduate farmers. Accordingly, the common support region was satisfied in the range of 0.03654173 to 0.8797614 with only 17 losses of observations (one from those FFS graduates and 16 from those non-FFS graduates farmers). Figure 1 below shows the regions of common support for the two groups of farmers.

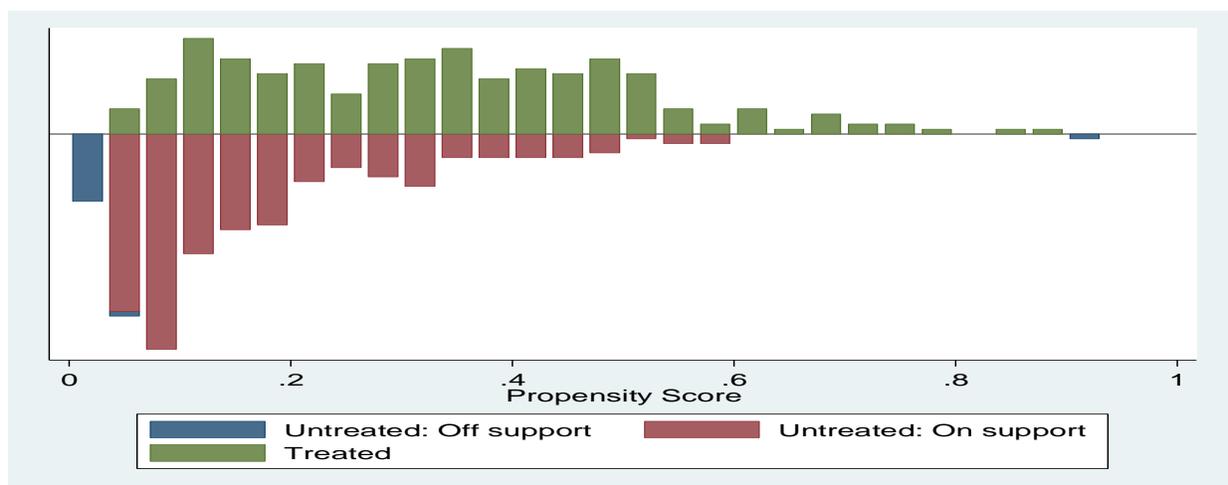


Figure 1. Propensity score distributions and common support for the propensity score estimation.
Source: own calculation from survey data

Note that “untreated off support” indicates those observations in the non-FFS graduates that do not have suitable comparison from the FFS graduates and hence excluded from the analysis while “untreated on support” indicates those observations in the non-FFS graduate that do have suitable comparison from the FFS graduates and used in the analysis. Thus, the graph clearly reveals that there is considerable overlap in the predicted propensity scores of the two groups. To verify whether the differences in the covariates in the matched two groups have been eliminated, we need to test covariate balancing. Accordingly, Table 3.5 presents results from covariate balancing test before and after matching. Mean standardized bias between the two groups after matching is significantly reduced for all matching algorithms suggesting that there is no systematic difference between the two groups after matching. The standardized mean difference which was around 26 percent for all covariates used in the propensity score before matching is significantly reduced to about five to seven percent after matchingⁱⁱⁱ, which has substantially reduced total bias to between 73.3 to 82.4 percent depending on which matching algorithm is used.

Table 3. 5: Quality of Matching before and after matching

| Algorithms | Before Matching | | | After Matching | | | Total bias reduction (%) |
|------------|-----------------------|---------------------|---------------|-----------------------|--------------------|---------------|--------------------------|
| | Pseudo R ² | LR X2 (P-value) | Mean std Bias | Pseudo R ² | LR X2 (P-value) | Mean std Bias | |
| NNM | 0.179 | 110.28 (p=0.000) | 26.2 | 0.042 | 23.82 (p=0.250) | 5.4 | 79.4 |
| RBM (0.01) | 0.179 | 110.28 (p=0.000) | 26.2 | 0.037 | 19.58 (p=0.484) | 7 | 73.3 |
| RBM(0.005) | 0.179 | 110.28 (p=0.000) | 26.2 | 0.029 | 12.08 (p=0.913) | 5.3 | 79.8 |
| KBM | 0.179 | 110.28 (p=0.000) | 26.2 | 0.01 | 5.93 (p=0.999) | 4.6 | 82.4 |

Notes : NNM = Nearest Neighbor Matching with replacements
 RBM (0.01) = Radius Based Matching with replacement using caliper of 0.01
 RBM (0.005) = Radius Based Matching with replacement using caliper of 0.005
 KBM = Kernel Based Matching

Source: own calculation from the survey data

In addition, comparisons of the pseudo R² and p-values of likelihood ratio test of the joint insignificance of all regressors obtained from the logit estimations before and after matching (Sianesi, 2004) shows that the pseudo R² is substantially reduced from about 18 percent before matching to about one percent in the case of kernel matching and to four percent with nearest neighbor matching. The joint significance of covariates was rejected since the p-values of

likelihood ratio test are insignificant in all matching cases. In sum, the high total bias reduction, lower pseudo R^2 , low mean standardized bias and insignificant p-values of the likelihood ratio test after matching suggests that the propensity score equation specification is successful in terms of balancing the distributions of covariates between the two groups of farmers.

Estimation of Farmers' Technical Efficiency

Following Battese and Coelli (1995) model, the mean of farm-specific technical inefficiency U_i , was estimated using equation 5 above. Table 3.6 below presents the estimates of stochastic frontier production function for maize farmers using pooled data of three years both for FFS graduate and non-FFS graduate farmers.

| Table 3. 6: Estimates of stochastic frontier production function for maize farmers (panel data) | | | |
|---|-------------|-----------|----------|
| Input variables | coefficient | St. error | t-ratio |
| Constant | 6.8057 | 0.0972 | 70.0289 |
| Maize land (hectare) | 1.1688 | 0.0558 | 20.9301 |
| labour used (man-days) | 0.1008 | 0.0172 | 5.8682 |
| Oxen labour (oxen days) | 0.0765 | 0.0204 | 3.7537 |
| DAP applied (kg) | 0.1106 | 0.1357 | 0.8150 |
| Urea applied (kg) | -0.0270 | 0.1406 | -0.1924 |
| Seed used (kg) | 0.0511 | 0.0310 | 1.6468 |
| compost used (qt) | 0.0311 | 0.0114 | 2.7150 |
| Year of observation | 0.0190 | 0.0299 | 0.6352 |
| Inefficiency variables: | | | |
| Constant | 9.7654 | 1.2695 | 7.6921 |
| Age of HH head | 0.0557 | 0.0162 | 3.4400 |
| Gender of HH head | -1.1409 | 0.5093 | -2.2401 |
| Marital status of HH head | -0.6680 | 0.2593 | -2.5766 |
| HH head can read and write | -0.0168 | 0.2527 | -0.0666 |
| Educational level of the HH head | 0.0503 | 0.0404 | 1.2457 |
| Farming experience of HH head in years | 0.0002 | 0.0160 | 0.0138 |
| HH family size (number) | -0.0777 | 0.0321 | -2.4190 |
| Average annual non farm income | 0.0001 | 0.0000 | 3.7598 |
| HH head has radio | -0.6236 | 0.1492 | -4.1795 |
| HH has land use certificate | -0.3815 | 0.2086 | -1.8286 |
| HH land [hectare] | -0.4320 | 0.0559 | -7.7333 |
| Distance from technology center[hrs] | 0.9483 | 0.1028 | 9.2283 |
| Average DA contacts | -0.0380 | 0.0091 | -4.1556 |
| Plough frequency | -2.7585 | 0.1878 | -14.6874 |
| Guto Gida District | -14.5711 | 0.7942 | -18.3459 |
| Gida Ayana District | -7.4981 | 0.5075 | -14.7759 |
| Time (year) | 0.0865 | 0.0954 | 0.9071 |
| Sigma-square ($\delta^2 = \delta u^2 + \delta v^2$) | 4.4100 | 0.3866 | 11.4071 |
| Gamma ($\gamma = \delta u^2 / \delta^2$) | 0.9911 | 0.0016 | 611.9111 |
| eta (η) | -0.0622 | 0.0251 | -2.4812 |
| ln (Likelihood) LR test | -1060.14 | | |
| Mean Technical Efficiency | 0.59 | | |

Source: Own calculation from the survey data

Before proceeding to the analysis of impact of FFS on the technical efficiency of the farmers, it was necessary to assess the presence of inefficiency in the production data for the sampled households. Given the specifications of the stochastic frontier production function defined by equation (5), the null hypothesis which states that technical inefficiency is not present in the model is expressed by $H_0: \gamma = 0$, where γ the variance ratio is explaining the total variation in output from the frontier level of output attributed to technical efficiencies and defined

by $\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2}$. The parameter γ must lie between 0 and 1; the closer the value of γ to zero,

indicates that the inefficiency effects are insignificant and vice versa. Accordingly, generalized likelihood-ratio tests of null hypotheses of the estimated parameters are presented in Table 3.7 below.

Table 3.7: Likelihood-ratio tests of hypotheses for parameters of the stochastic frontier production function

| Null Hypothesis | Log likelihood | λ^* | Critical value | Decision |
|---------------------------|----------------|-------------|----------------|----------------------------|
| Given Model | 1060.14 | | | |
| $\gamma = 0$ | 1493.86 | 867.43 | 6.63 | Reject the null hypothesis |
| $\mu = \gamma = \eta = 0$ | 1337.10 | 553.92 | 11.34 | Reject the null hypothesis |
| $\mu = \eta = 0$ | 1337.10 | 553.92 | 9.21 | Reject the null hypothesis |
| $\mu = 0$ | 1336.96 | 553.63 | 6.63 | Reject the null hypothesis |
| $\eta = 0$ | 1276.27 | 432.26 | 6.63 | Reject the null hypothesis |

Source: own calculation from survey data

The first null hypothesis tested states that technical inefficiency is not present in the model $H_0: \gamma = 0$ was strongly rejected. Similarly, the null hypotheses that states technical inefficiency effects are time invariant and that they have half normal distribution defined by $H_0: \eta = 0$ and $H_0: \mu = 0$ were also strongly rejected. As the estimated parameter η was found to be significantly negative, which was -0.0622 at [t=2.5], it means that the technical efficiency of the sampled farmers decreases over time. It was also proved that the inefficiency effects in the stochastic frontier are clearly stochastic and are not unrelated to the household and farm specific variables and year of observation included in the model. The rejection of the null hypothesis which states that parameter μ is zero implies that truncated-normal distributional assumption of one sided error term is more appropriate for the farmers in the study area than half-normal distributional assumption.

The signs of the coefficients of the stochastic frontier are as expected, with the exception of the negative estimate of the urea applied. The estimated elasticities of mean output with respect to

land, human labour, and oxen labor are 1.1688, 0.1008, and 0.0765 respectively. This means that for a 10 percent increase in area cultivated with maize, results in increase in maize output by 11.68 percent, which shows the importance of farm size for maize production. This could be related to achievement of economies of scale. Similarly, a 10 percent increase in the amount of human labour increases maize output by 1.01 percent, again indicating the significance of human labor for maize production. A 10 percent increase in oxen labour increases maize output by about 0.8 percent. The estimated elasticity for compost is 0.0311 implying that a 10 percent increase in the amount of compost applied increases maize output by 0.31 percent and this result is statistically significant at 1 percent.

As the estimated coefficients in the inefficiency model are more relevant for this study, it is reasonable to discuss them here. As expected, the *age* coefficient is positive, which indicates that the older farmers are more inefficient than the younger ones. This could be because the elders lack the required capacity to deal with routine agricultural work and or because they lack literacy. The negative estimate for *gender* implies that the males are more efficient than females. This is actually true in the reality of the study areas as females are usually preoccupied with in-house activities including child caring while the agricultural activities which demand more labour are customarily considered as the responsibility of males. Similarly the negative sign for *literacy* implies that farmers who can read and write tend to be more efficient. The coefficient of *family size* is negative implying the importance of labour for maize production. Those farmers who have more non-farm income tend to be more inefficient and this is statistically significant at 1 percent. Other variables such as having *radio*, *land use certificate*, *land size* have negative signs showing that the one who have radio may acquire updated information and hence tend to be more efficient, while having land use certificate will increase their tenure security and hence more efficiency. The negative sign for *land size* is consistent with the importance of larger farm land for achievement of scale of economies. *Plough frequency* has the expected large negative signs with statistical significance showing that if maize land is ploughed many times before planting, he/she would be much efficient. Dummy variables for the districts show negative sign implying that sampled farmers in Guto Gida and Gida Ayana are more efficient than farmers in the Boneya Boshe district. The positive coefficient for *year* variable in the inefficiency model, although statistically insignificant, suggests that the inefficiencies of the maize farmers tended to increase over the years. This is also confirmed by the decreasing mean technical efficiency of the farmers which was 0.60 during the year before the FFS training and reduced to 0.59 during the subsequent two years after the training. The estimate for the variance parameter, γ , is 0.9911 which is close to one, indicating that the inefficiency effects are likely to be highly significant in the analysis of the value of output of the farmers. Furthermore, the estimates for parameters of the time varying inefficiencies model indicate that the technical inefficiency effects tend to increase over time since the parameter η is estimated to be negative (-0.0622), which is significant at 5 percent level of significance.

Impact estimation using PSM

Our main interest in this section is to see if the FFS training program has brought any desirable change in the technical efficiency of the FFS graduate farmers as compared to non- FFS graduates. For this, the estimated technical efficiency for each farmer in the sample from the equation 5 was used as dependent variable in the models specified by equation 13 above so as to examine the technical efficiency difference between the two farmer groups. Accordingly, comparison of technical efficiency across farmers groups is presented by Table 3.8.

Table 3. 8: Comparison of technical efficiency across farmer groups

| Command | Algorithms | FFS Graduate (N) | Non FFS (N) | ATT | Std.Err | T |
|----------|------------|------------------|-------------|---------|---------|----------|
| Psmatch2 | Attn | 217 | 228 | -0.0178 | 0.0336 | -0.53000 |
| | attr 0.01 | 202 | 228 | -0.0011 | 0.0310 | -0.04000 |
| | attr 0.005 | 177 | 228 | 0.0028 | 0.0320 | 0.09000 |
| | Attk | 217 | 228 | 0.0094 | 0.0285 | 0.33000 |
| Pscore | Attn | 217 | 94 | 0.027 | 0.038 | 0.72900 |
| | attr 0.01 | 191 | 212 | 0.022 | 0.024 | 0.90000 |
| | attr 0.005 | 174 | 199 | 0.025 | 0.025 | 0.98000 |
| | Attk | 217 | 212 | 0.023 | 0.03 | 0.77300 |

Source: own calculation from survey data

The result shows that the estimated coefficients are very small, inconsistent among different matching algorithms and all statistically insignificant implying that the FFS graduate farmers do not seem different from other farmers in terms of their technical efficiency. The result is also consistent with the implications of descriptive statistics explained above.

Impact Estimation using DID

In this section, household technical efficiency index estimated by equation 5 was used as dependent variable in the impact estimation function specified by equation 15 above. In addition to the participation dummy of *FFS*, various household and village characteristics were also included as explanatory variables. However, as most household and village characteristics were almost stable over the three periods, most of them were eliminated by differencing operation. As there could be significant differences of performance among farmers in different districts, it is meaningful to include two district dummies Guto Gida and Boneya Boshe to control for the district specific unobserved factors, while Gida Ayana was made implicit in this case.

Since heteroscedasticity may cause problem to the “difference in difference” models (Wooldridge, 2002; Leifeng, 2010; World Bank, 2010), we have tested for the existence of such problems. We have observed that Breusch-Pagan Tests detected existence of significant heteroscedasticity for estimated function. Therefore, we have reported the robust standard errors

as correction for heteroscedasticity problem. However, since there was only one period left after differencing, there was no need of testing for serial correlation in the model.

Consistent with the technical efficiency estimates reported above, all variables included in the estimates of technical efficiency growth rate are found to have the expected signs. Table 3.9 provides the estimates of technical efficiency growth rate.

Table 3. 9: Estimated impact on FFS graduate technical efficiency using DID

| Dependent variable: Technical efficiency | | | | | | |
|--|----------------|---------------|-------------------------|---------------|-------------------|----------------|
| Variables | Coef. | St. Err | t | P> t | 5% Conf. Interval | |
| N=446 | F= 7.1700 | | R ² = 0.5400 | P= 0.0000 | | |
| Constant | -0.0390 | 0.0093 | -4.2000 | 0.0000 | -0.0572 | -0.0208 |
| FFS Graduates | -0.0257 | 0.0096 | -2.6700 | 0.0080 | -0.0445 | -0.0068 |
| Plough frequency | 0.0435 | 0.0187 | 2.3300 | 0.0200 | 0.0069 | 0.0801 |
| Fertilizer used | 0.0000 | 0.0001 | -0.0700 | 0.9470 | -0.0002 | 0.0002 |
| Maize farm | 0.0064 | 0.0097 | 0.6600 | 0.5080 | -0.0126 | 0.0254 |
| Family labor | 0.0008 | 0.0002 | 3.5000 | 0.0000 | 0.0004 | 0.0013 |
| Hired labour | -0.0001 | 0.0003 | -0.4500 | 0.6540 | -0.0008 | 0.0005 |
| Herbicide | -0.0024 | 0.0051 | -0.4800 | 0.6310 | -0.0124 | 0.0075 |
| Tractor use | 0.0000 | 0.0000 | 0.1900 | 0.8480 | 0.0000 | 0.0000 |
| Compost | 0.0008 | 0.0009 | 0.9200 | 0.3570 | -0.0009 | 0.0026 |
| DA visits | -0.0006 | 0.0007 | -0.8700 | 0.3870 | -0.0021 | 0.0008 |
| Guto Gida | 0.0463 | 0.0126 | 3.6600 | 0.0000 | 0.0214 | 0.0711 |
| Boneya Boshe | 0.0862 | 0.0117 | 7.4000 | 0.0000 | 0.0633 | 0.1091 |

Source: own calculation from the survey data

Consistent with the descriptive analysis discussed above, FFS graduate farmers are identified with statistically significant lower technical efficiency growth rate. The model estimate shows that participation in the FFS training program has reduced their technical efficiency growth rate by about 0.3 percent and this difference is statistically significant at 1 percent. The Farmers have reported that shortage of time to deal with their routine agricultural practices become the major hindrance for their production and productivity enhancement. They have stated that they are overloaded by the frequency of meetings and short term trainings of various types, participation in rural community road construction as well as in natural resources conservation practices which usually coincide with their farm field preparation seasons. The farmers have actually reported that their efficiency declines over time not because of lack of the required technical skills but mainly because of lack of time and financial resources to undertake the required agricultural practices at right time. The model farmers expressed their concern over the natural resources conservation and rural road construction practices that they are required to do for a minimum of 30 days each year. Such practices not only consume their agricultural time but also severely curtail their efficiency as they are more frequently injured while doing such heavy tasks as digging holes, rolling of rocks and carrying of heavy woods.

Other variables such as plough frequency, application of family labor and dummy variable representing the districts have all statistically significant coefficients. The results showed that family labor significantly and positively influences efficiency, while hired labor showed the contrary effect on efficiency. As the microeconomic theory states, in the absence of strict supervision and monitoring, hired laborers fail to increase efficiency owing to their morale hazard problem. The statistically significant positive coefficients of Guto Gida and Boneya Boshe districts implies that, on average, farmers in both districts have higher technical efficiency growth rate than farmers in the Gida Ayana district.

SUMMARY AND CONCLUSIONS

The paper assesses the impacts of Farmer Field School (FFS) on farmers' technical efficiency change approximately two years after the launch of the program, which is sponsored by the Ethiopian government in 2010. Mainly two estimation methods are adopted to arrive at the results that help to assess the impacts: Propensity Score Matching (PSM) with numerous matching algorithms and Difference-in-Difference (DID). The PSM method helps to match program participating farmers and non-participating farmers based on their baseline similarities and clear out those factors to single out only program impacts. Difference-in-Difference approach helps to difference out unobservable factors from the impact analysis process.

Both PSM and DID estimates showed that FFS graduate farmers were identified with statistically significant lower technical efficiency growth rate as compared to non-FFS graduates. The model estimate shows that participation in the FFS training program has reduced their technical efficiency growth rate by 0.3 percent and this difference is statistically significant at 1 percent. Such decreasing trend in the technical efficiency of the FFS graduate farmers was explained by their reduced family labour allocation per hectare of their farmlands. It was found that as the FFS graduate farmers allocate most of their time for numerous mandatory meetings, trainings, community mobilization and their heavy involvement in political canvassing, they tended to use more hired labour than maximizing their own labour for the routine agricultural practices. In addition, most FFS graduate farmers substituted applications of herbicide chemicals in lieu of manual weeding and hence their cash cost of maize production increases over time while their technical efficiency declines owing to lack of time to monitor those paid laborers. Thus, the FFS graduates couldn't increase their technical efficiency for the reasons that the FFS program has put disproportionately higher burdens on the FFS graduates which sharply contradicts with farmers' own production decisions. The policy implication of this paper is that it is really important for the government to consider the timing of mandatory trainings, meetings and community works so that such activities should not coincide with the peak time of agricultural land preparation and harvesting times of the farmers.

At the end, although we have employed a number of sophisticated econometric models appropriate for impact evaluation design, there are words of caution with regard to our conclusions. Firstly, given the fact that FFS training program was the national agenda operating in all regions of the country all at the same time, selection of representative districts and households were a real challenge given the very limited research fund and time available. As the result, data for this study were collected only from three purposively selected maize producing districts and from each district only one Kebele from where households were randomly selected. Thus, although this approach has enabled us to positively contribute to impact assessment literature and agricultural policy makers, it might have come at some expense of representativeness. Secondly, although the chosen locations are representative for maize producers in the region, we are not sure how well those locations represent the average conditions under which the FFS training program was implemented in the country and its impacts on other agricultural crops. Thirdly, although it is true that the lessons learned from FFS program would be forgotten if not used to practices shortly, by assessing program impact just two years after the program intervention, we may be capturing only medium term impacts that may or may not last over time. In essence, the estimated impact shows just impacts after two years of program implementation, and hence do not show any possible dynamisms of the impact in the long run. Finally, as this study has considered only impact on the technical efficiency of maize farmers, no claim is made with regard to program impacts on other aspects such as general socio-economic development, environmental conservations, health, and political sustainability that the program might have impacted on.

Notes

ⁱ Psmatch2 is Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and Covariate imbalance testing developed by Leuven and Sianesi (2003).

ⁱⁱ Pscore was developed by Becker and Ichino (2002) for the estimation of average treatment effect based on propensity score. Although the estimated effects under both commands may differ, both estimates are expected to lead to the same conclusion if the detected impact estimation results are robust enough.

ⁱⁱⁱ Rosenbaum and Rubin (1985) suggested that a standardized mean difference greater than 20 percent should be considered too large and an indicator that the matching process has failed.

REFERENCES

- Bamlaku .A., E-A Nuppenau and H. Boland .(2009), “Technical Efficiency of Farming Systems across Agro-ecological Zones in Ethiopia”: An Application of Stochastic Frontier Analysis. *Agricultural Journal* 4(4): 202-207,
- Battese, G.E. and T.J. Coelli (1995), “A Model for Technical Inefficiency in a Stochastic Frontier Production Function for Panel Data”. *Empirical Economics*, 20:325-332.
- Bravo-Ureta, Boris E., and Robert E. Evenson. (1994), “Efficiency in Agricultural Production: The Case of Peasant Farmers in Eastern Paraguay.” *Agricultural Economics* 10, no. 1: 27–37.
- Bryman, A. (1988), “Quantity and Quality in Social Research.” London: Unwin Hyman
- Essama-Nssah, B. (2006), “Propensity Score Matching and Policy Impact Analysis: A Demonstration in Eviews”. Poverty Reduction Group (PRMPR). The World Bank Washington, D.C.
- Farrell, M. J. (1957), “The measurement of productive efficiency”, *Journal of Royal Statistical Society, (Series A)*, 120:253-281.
- FDRE, MoFED .2014. Growth and Transformation Plan Annual Progress Report for F.Y. 2012/13. Addis Ababa, Ethiopia, February 2014
- FDRE, MoA (2014), “Project Proposal for Blended Fertilizer Plant Establishment at Gibe Didessa Farmers’ Cooperative Union. A proposal to build a sustainable fertilizer blending business in Ethiopia and drive local adoption of blended fertilizer, Addis Ababa, Ethiopia, March 2014
- FDRE, MoARD. (2010), “Ethiopia’s Agriculture Sector Policy and Investment Framework: Ten Year Road Map (2010-2020)” Addis Ababa, Ethiopia, May 3, 2010
- Feder, G., R. Murgai, and J.B. Quizon. (2004b), “The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia”. *Journal of Agricultural Economics* 55 (2): 217–239.
- Feder, Gershon, Rinku Murgai, and Jaime Quizon. (2004a), “Sending Farmers Back to School: The Impact of Farmer Field Schools in Indonesia.” *Review of Agricultural Economics* 26, no. 1:45–62.
- Heckman, James J., Ichimura, Hidehiko, and Todd Petra. (1998), “Matching as an Econometric Evaluation Estimator”. *Review of Economics Studies* 65:261-294.
- Heinrich. C, A. Maffilo and G. Vazquez . (2010), “A Primer for Applying Propensity-Score Matching. Impact-Evaluation Guidelines Technical Notes” No. IDB-TN-161. August 2010
- IDB- Inter-American Development Bank. (2010), “Designing Impact Evaluations for Agricultural Projects Impact-Evaluation Guidelines Technical Notes” No. IDB-TN-198 December 2010. Inter-American Development Bank, Washington, D.C.
- IDB -Inter-American Development Bank. (2010), “Development Effectiveness Overview, Special Topic, Assessing the Effectiveness of Agricultural Interventions”. Inter-American Development Bank, Washington, D.C.
- IFPRI. (2010), “Fertilizer and Soil Fertility Potential in Ethiopia: Constraints and opportunities for enhancing the system”, July, 2010. <http://www.ata.gov.et/projects/ethiopian-soil-information-system-ethiosis/>
- Imbens, Guido W. (2004) “Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review”. *The Review of Economics and Statistics* 86(1): 4-29.

- Lifeng, W. (2010), “Farmer Field School and Bt Cotton in China: An Economic Analysis”.
Doctoral Thesis. University of Hannover. Pesticide Policy Project Publication Series
Special Issue No. 15, Murch 2010
- Ravallion, M. (2008), “Evaluating Anti-poverty Programs.” In Handbook of Development
Economics, vol. 4, ed. T. Paul Schultz and John Strauss, 3787 846. Amsterdam: North-
Holland.
- World Bank, (2010), “Handbook on impact evaluation: quantitative methods and practices”.
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