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Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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Paper submitted to be presented at the Fifth Conference of the African Association of Agricultural Economists (5th CAAAE)

Abstract

The objective of this study is to evaluate the effect of Farmer Field Schools (FFSs) on cocoa yield in the Centre and South-west regions in Cameroon. The evaluation of FFSs is important for improving cocoa production by agricultural research and extension. This evaluation is done by using the “Propensity Score Matching” technique and Rosenbaum bounds sensitivity analysis method to ensure robustness of results. The data comes from IITA surveys conducted in 2009 and concerned 201 cocoa farmers in the Centre and South -West Regions in Cameroon for the 2008/2009 cocoa season. The sample cocoa farmers contain participants and non participants to FFSs. Results show that participate to FFSs have a positive and significant effect on the cocoa yield per hectare. This effect is estimated at about 97 kilograms per hectare. This effect is statistically significant at 10%, only for the kernel matching but not for the five nearest neighbors matching. This weak significant of FFS impact could be lead to the fact that farmers who joined FFS are those who have low capacity in cocoa production compare with those who did not joined FFS. This can also lead to the poor quality of FFSs training. The first recommendation is to promote the FFSs in the area where there is no FFSs by highlighting agricultural extension service. The second recommendation is to improve the quality of training in Farmer Fields Schools in other to increase their impacts on cocoa yield.

In the current context of agricultural intensification challenges in developing countries, this analytical framework is of interest for policy makers for identifying conditions of farmer participation to FFSs and designing effective motivation strategies.

Key words: Farmer Field School, intensification, participation, impact, cocoa yield, Cameroon.

JEL: Q16, Q18

1. Context and Problem Statement

The process of cocoa intensification in developing countries remains a great debate although cocoa has been grown in these countries since the early 1900s. To improve cocoa intensification, extension programs have used traditional top down approaches such as the training and visit approach but, the results have been disappointing (David, 2008). The main transformation up to now remains the Farmer Field Schools (FFS) training carried out by the Sustainable Tree Crops Program (STCP) since 2004 in Cote d'Ivoire, Ghana, Nigeria and Cameroon. A basic premise of STCP was: i) produce cocoa sustainably; ii) small-scale farmers need to develop knowledge of biological processes and iii) understand interactions in the cocoa agro-ecosystem to be able to make sound management decisions.

The objective of FFSs training with STCP program is to allow farmers to make their own discoveries about management practices that reduce their dependence on costly inputs such as pesticides and improve their understanding of crop and pest management. Farmer training focuses on integrated crop and pest management (ICPM) with specific emphasis on good crop husbandry, pest and disease management, the use of rational pesticide, farm renewal and cocoa quality. Farmers also learn about social topics such as responsible labour practices, HIV/AIDS and how to work in groups (David, 2008).

These FFSs training seeks to alleviate the insufficiency of the traditional extension approaches. Thus, FFSs trainings are conducted by facilitators who are extension agents or farmers who have gone through a comprehensive Training of Trainers (TOT) program on participatory training of cocoa farmers' agents. Therefore, FFSs training teaches farmers on the best mix of pest management techniques which includes crop management methods, use of improved planting material/varieties, preserving and/or manipulating biological agents and the use of chemical pesticides. FFSs graduates had attended a significantly higher number of training events (at least 8 sessions of training) compared to non-participants. Cocoa extension activities focused on blanket technical messages without much emphasis on understanding interactions within the cocoa agro-ecology and factors contributing to diseases and pests (David, 2008). The main criterion of creating FFSs in a given village is based on the existence of farmer organisation or farmer association which regroups a certain number of farmers to be trained. Thus, the number of available farmers determines the number of FFSs to be created. One FFS has about 20 farmers. However, other criteria for creating FFSs could be the willingness of farmers to be trained by FFS and to have a portion of cocoa farm (There is no limitation to the farm size). There is no other constraint for farmers to joint FFSs. The promotion of FFSs was driven by the STCP program hosted by IITA and which was conducted in the same manner in the two regions (Centre and South-west) which are the main regions of cocoa production in Cameroon. It is important to note that, the South-west region is different from the Centre region. In fact due to its agro-climatic characteristics, the South-west region is more favourable to cocoa production. Moreover, the farms in this region are larger (on average three times larger), production is more intensive and output is three times higher (900-1,000 kg / ha compared to 300-450 kg / ha in the centre region) (Gilbert et al., 1999). Thus, after about 4 years of implementing ICPM through the FFSs training in

Cameroon, we can be bound to one essential question: ***What is the impact of cocoa FFSs on cocoa yield in Cameroon?***
To answer this question, we use data from a survey conducted by IITA in 2009. Our Study will consist of highlighting the effect of cocoa FFSs on cocoa production by comparing FFS-participants and non-participants.

2. Literature Review on Farmer Field Schools

In recent years, a number of development agencies have promoted FFSs as a potentially more effective approach to extend knowledge to farmers. FFSs programs were first introduced in East Asia in the mid 1990s, as a way of diffusing knowledge-intensive integrated pest management (ICPM) practices for rice (Godtland et al., 2004).
Today, the approach of FFSs has become popular and exists in at least 89 countries (Braun, et al., 2006). The concept of FFSs remains the new efficient technique of training farmers in various crops. This technique was introduced in response to a major pest outbreak, that was caused by the misuse of pesticides on rice farms. The FFSs approach has been extended throughout Asia and to several countries in Africa and Latin America. In Sub-Saharan Africa, the approach of FFSs has been extended to more than 27 countries between 1993 and 2003 (braun & Duveskog., 2008). FFSs are generally being conducted by a wide range of international institutions in Africa (such as FAO, IITA, DANIDA… etc,) and many governments, and numerous non-governmental organizations (NGOs).
Few studies have evaluated the impact of FFSs on agricultural production. Godtland et al. (2004) found in their study that farmers who participated in the program had significantly more knowledge about ICPM practices than those in the non-participant comparison group. Thus, improve of knowledge about ICPM practices has the potential to significantly improve productivity in potato production.
Mutandwa & Mpangwa (2004) in their study found that agricultural yields, cotton incomes and technical knowledge scores for FFS participants were greater than for non-participants. Moreover, Zuger (2004) found that, the only benefit resulting from Farmer Field Schools is the significant and statistical increase in yield. Recently, the study of Davis et al. (2012) shows that participation in FFSs improves overall agricultural income and crop productivity. In addition, Waddington et al. (2014) suggested from their findings the promoting within FFSs, integrated pest management (IPM) technology, as well as other techniques.
At its introduction in Africa, the focus of FFSs was on production and pest management (PPM) because of the relatively low levels of production and pesticide usage. In the Central Africa, FFSs have been introduced in Cameroon through the STCP program since 2003 in the cocoa sector. Today about 45000 cocoa farmers have been directly trained through FFSs for an estimated cocoa area of 45000 hectares.

3. Methodology

In this study, we seek to highlight the impact of cocoa FFSs on cocoa yield in Cameroon. This is done through the non parametric model which is the “propensity Score Matching” technique. Rosenbaum bounds sensitivity analysis method is use to ensure robustness of results.

3.1 Estimating method of propensity score matching

The matching process is therefore performed in three steps. First, we used a logit model to estimate the propensity score. Second, we estimated the ATT, conditional on the propensity score (Common support determination and Estimating of Standard Error); and third, we analyzed the effect of unobservable influences on the inference about impact estimates

The principle of estimating method is to use collected information about untreated individuals to build a counterfactual for each treated individual. Thus, the average treatment effect on treatment is:

$$\Delta^{ATT} = E(Y_T - Y_{NT} \mid T = 1) = E(Y - Y \mid T = 1)$$

$$= E[Y - E(Y \mid X, T = 0) \mid T = 1]$$

$$= [E(Y_T \mid T = 1, X = x) - E(Y_{NT} \mid X, T = 0, X = x)]$$

The estimator Δ^{ATT} is obtained as the average of all differences between the situation of treated individuals and the built counterfactual.

The problem becomes estimating $E(Y_{NT} \mid X = x_i, T = 0) = f(x_i)$, for each treated individual with characteristics x_i. To reach the result, one must first make pairing on the base of "Propensity Score Matching". Then the next step will just be a question of defining the common support and calculating the variations.

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3.2 Rosenbaum bounds sensitivity analysis method

A Rosenbaum bounds sensitivity analysis will be conducted to estimate the extent to which selection on unobservables may bias the estimates of the ATT. A sensitivity analysis determines the magnitude of hidden bias that would need to be present to alter the conclusions of an observational study (Rosenbaum, 2002). In fact, if there are unobserved variables which affect assignment into treatment and the outcome variable simultaneously, a "hidden bias" might arise. It should be clear that matching estimators are not robust against this "hidden bias" (Caliendo & Kopeinig, 2008). Since it is not possible to estimate the magnitude of selection bias with non-experimental data, we address this problem with the bounding approach proposed by Rosenbaum (2002). The basic question to be answered is, if inference about treatment effects may be altered by unobserved factors? In other words, we want to determine how strongly an unmeasured variable must influence the selection process in order to undermine the implications of matching analysis. The Rosenbaum bound sensitivity analysis method assumes that there is an unmeasured covariate (u_i) that affects the probability of participation. If $P(x_i)$ is the probability that individual i participates in FFSs, and x is the vector of observed covariates, then the probability to participate in FFSs is given by:

$P(x_i) = P(D_i = 1/x_i) = F(\beta x_i + \gamma u_i)$ where x_i are the observed characteristics for individual i, u_i is the unobserved variable and γ is the effect of u_i on the participation decision. Thus, if there is free hidden bias, γ will be zero and the participation probability will solely be determined by x_i. However, if there is hidden bias, two individuals with the same observed covariates x have differing chances of receiving treatment. Assuming that F follows logistic distribution, the odds ratio of two matched individual (i and j) participating in the FFSs (receiving the treatment) may be written as:

$$\left(\frac{P(x,u_i)}{P(x,u_j)} X \frac{1-P(x,u_j)}{1-P(x,u_i)}\right) = \frac{e^{\beta_i x_i+\gamma_i u_i}}{e^{\beta_j x_j+\gamma_j u_j}} = e^{[\gamma(u_j-u_i)]}$$

This equation states that two units with the same x differ in their odds of receiving the treatment by a factor that involves the parameter γ and the difference in their unobserved covariates u. As long as there is no difference in u between the two individuals or if the unobserved covariates have no influence on the probability of participating in FFSs ($\gamma = 0$), the probability of participating will only be determined by the x vector and the selection process is random. $\gamma > 0$ implies that two individuals with the same observed characteristics have different chances of participating in FFSs due to unobserved selection bias. In our sensitivity analysis, we examined how strong the influence of γ or $(u_j - u_i)$ on the participation in FFSs process needs to be, in order to attenuate the impact of participating on potential outcomes (Rosenbaum, 2002).

Following Rosenbaum (2002), the odds ratio of two matched individual (i and j) participating in FFSs can be rewritten as: $\frac{1}{e^{\gamma}} \leq \frac{P(x,u_i)[1-P(x,u_j)]}{P(x,u_j)[1-P(x,u_i)]} \leq e^{\gamma}$

implying that varying the value of e^{γ} allows one to assess the sensitivity of the results with respect to hidden bias and to derive the bounds of significance levels and confidence intervals. The intuitive interpretation of the statistics for different levels of e^{γ} is that matched individual may differ in their odds of being treated by a factor of e^{γ}, as a result of hidden bias. If $e^{\gamma} = 1$ ($\gamma = 0$), then this corresponds to no selection bias on unobservables; in which case, the odds ratio becomes one: the two units are equally likely to get treated. If $e^{\gamma} = 2$, then two individuals who appear to be similar on x vectors could differ in their odds of participating in FFSs by a factor of 2; so one of the matched individuals may be twice as likely to participate as the other individual (Rosenbaum, 2002). In this sense, e^{γ} can be interpreted as a measure of the degree of departure from a situation that is free of hidden bias. If values of e^{γ} close to 1 change the inference about the participation effect, the estimated participation effects (ATT) are said to be sensitive to unobserved selection bias and are insensitive if the conclusions change only for a large value of $e^{\gamma} > 1$ (Aakvik, 2001; Rosenbaum, 2002)). Estimating Rosenbaum bounds involves calculating and ranking the differences in outcomes of the treated and control groups.

3.3 Data

This study aims at evaluating the effect of FFSs on cocoa farmers in Cameroon. It is based on data relating to 201 farmers in the Center and South-west regions. These data result from a survey carried out by IITA[1] in 2009. Our Study will consist of highlighting the effect of cocoa FFSs by comparing FFS-participants and non-participants. The sampling strategy that we adopted aims at circumventing the various sources of selection bias. Thus, the differences between FFS participants and non-participants can be completely or partially attributed either to farmers, or to the effect of FFSs. Then, the source of selection bias can come from certain non-observable characteristics at the regional, producers' or FFSs level. At the level of the region, a dynamics of farmers can come partly from the elites. At farmer level, there are entrepreneurial spirits and the relations which farmers can have with other farmers. Such bias is often considered by using the method of instrumental variables. But this method is limited when a treated observation significantly affects the result of another untreated observation by external effects. Lastly, the source of selection bias can come from externalities exerted by FFSs on farmer capacity and/or the choice of farmer to participate. Techniques which were intensely developed in many economic impact evaluation theories are still not quite applied in empirical studies. (Jalan & Ravallion, 2003a). Concerning our study, the application of these techniques starts with previous studies as: impact evaluation of potatoes farmer field school (Godtland et al., 2004), impact social fund development (Rao & Ibáñez, 2005), impact evaluation of the piped water (Jalan & Ravallion, 2003b), impact evaluation of road rehabilitation(Van de Walle, 2009) and impact evaluation of co-operatives(Bernard et al., 2008 and Bernard and al., 2009). Our approach in one step consists in matching FFSs participants with the similar non participants. This matching enables us to consider the three forms of bias, since it considers at the same time the observable and non-observable characteristics of farmers and region. Finally, to be sure of the validity of these techniques, it is necessary that the treatment sample and comparison sample both operate in the same environment (Heckman et al., 1997). For our case, we make sure that in the matching framework, farmers are sufficiently similar by considering various characteristics of farmers and regions (farm size, farmer's age, farmer's level of education, pesticides used, etc).

Limitations of PSM method: One of the limits of this method is that the application of Propensity Score Matching technique does not enable to minimize all the three categories of biases. Indeed, the second category of bias (i.e bias related to the unobservable characteristics), is not minimized by this technique. This technique only enables to minimize the first category of bias (i.e related to the observable characteristics) and the third category of bias (i.e related to the externalities). In fact, the matching will only control for the differences on the observed variables and there may be some bias resulting from the unobserved covariates that could affect whether subjects receive treatment or not. Furthermore, this method will not be useful if subjects with a high propensity score were treated and those with a low propensity score were untreated.

[1] International Institute of Tropical Agriculture

This study will use data collected from two regions in Cameroon: Center and South-west regions which constitutes the highest percentage (85%) of national cocoa production in Cameroon. The data were collected through a questionnaire administered by IITA for an "impact of farmer training survey" of STCP[2] program. This survey covered the period running from March 2009 and concerned cocoa farmers. From both regions, data were collected on 201 farmers (Table 1). We followed different surveyors' teams in the field as supervisor and coordinated data entry survey. The survey was carried out by 04 surveyors (02 surveyors in the Center and 02 surveyors in the South-west). Farmers were selected on purely random basis for participants and non-participants in each region.

Among 201 farmers from whom data were collected, 101 farmers received treatments or were members of the Farmer Field Schools and 100 farmers served as the control for the estimation of the impact factor. Table 2 summarizes variables used in estimating the Propensity Score Matches (PSM) and the Average Treatment Effects on the Treated (ATE). The existence of variables for the years 2008 and 2009 is related to the fact that in the questionnaire, some questions relate to farm characteristics (Equipment, production and use of pesticides) for the current season (2008/2009) and the previous season (2007/2008). But, to avoid confusion, we have obtained for each variable mean in 2008 and 2009 seasons. Thus the study evaluates the impact of FFSs on cocoa production between 2008 and 2009 seasons.
We use knowledge variable as explanatory variable because we assume that some farmers who never attended FFSs can make knowledge on cocoa production practice, while other farmers who attended the FFSs did not apply their knowledge very well on their farms.

4. Results

This study aims at measuring in a robust way the effect of FFSs on cocoa production. The challenge faced here consists in reducing considerably the measurement bias by using the technique of "propensity score matching". Our study enables us to quantify by minimizing bias, the impact of FFSs cocoa yield in Cameroon. Table 3 presents descriptive statistics of variables used in the analysis with performed t-tests to test for statistical significance between participants and non-participants.

To address the possible sample selection bias, we run the PSM, the Rosenbaum bounds sensitivity analysis and Switching Regression.

4.1 Estimation of the probability propensity score

The dependent variable in the PSM is farmer participation in STCP-FFS Training (FFS). The results of probit estimation of FFS are presented in Table 4. These results show that the participation in FFS is influenced by the probability of farmer to be male or female (MALE), the capital equipment cost of farmer (CAPITAL EQUIPMENT), the number of shade tree in the farm (SHADE TREE) and the cost of pesticides used in the farm (PESTICIDES COST).

[2] Sustainable Tree Crop Program

The distribution of "propensity scores" between treatment and control groups is shown in Figure 1. This figure clearly shows that the two distributions are different.

To ensure the robustness of our estimations, several techniques can be used. We focus on two commonly used methods: nonparametric kernel regression matching proposed by Heckman et al., (1998) and five nearest neighbours matching. In the first technique, each producer treaty is matched with the entire sample of comparison. However, for each observation in the treatment group, an observation which is the weighted average of observations in the control group is generated. Those weights are made inversely proportional to the distance between each observation concerned and the control group observations, on the base of “propensity score" distribution. In the second technique, each treated observation is paired with the average of its five nearest neighbours of comparison sample, always based on "propensity score" distribution. To ensure maximum comparability of treatment and comparison group, the sample is restricted to the region of common support defined by the values in the range of "propensity score" in which treatment and control observations can be found.

The right way to test the validity of matching is to compare characteristics averages of farmers in the treated sample with the corresponding characteristics of the control group generated. Therefore, the absence of significant differences between treatment and control groups confirms the validity of matching. Thus, we undertook a series of statistical tests of farmer’s characteristics and trading difference in three samples: the sample of unmatched farmers, the sample of farmers matched with kernel technique and the sample of farmers matched with five nearest neighbours technique. Table 5 shows the significant difference in the vast majority of characteristics in farmers sample unmatched (FFS-participants with Non FFS-participants). In summary, matched samples ensure the validity of the comparability required.

4.2 Average effect of FFS: PSM approach

The indicator of FFSs impact is cocoa yield per hectare. The impact of FFSs on cocoa yield shows whether FFSs enable cocoa farmers to increase their yield. Table 6 presents the results of average treatment effects estimation for FFSs participation. To ensure the robustness of this estimation, we first calculated the difference in the output variable (farmer cocoa yield) between treatment group and the control group. Then, for the standard error, we made 100 replications bootstrap in Stata Program.

The results of average effects estimation for both methods (for Kernel matching and matching five-nearest neighbosrs) show that farmers who participate in FFSs increase their yield for about 97 kilogram per hectare more than those who do not. This effect is statistically significant at 10%, only for the kernel matching but not for the five nearest neighbors matching. This weak significant of FFS impact could be lead to the fact that farmers who joined FFS are those who have low capacity in cocoa production compare with those who did not joined FFS.

The Rosenbaum bounds sensitivity analysis is obtained using the "mbounds" command in Stata12. The results are not significants. As noted by Hujer al., (2004), sensitivity analysis for insignificant ATT estimates is not meaningful and thus we did not present the results.

5. Conclusion and Recommendations

The importance of FFSs carried out by STCP program is to have farmers' positive benefit generated from externalities for those who participate. The objective was to assess the impact of cocoa FFSs on cocoa yield. Analysis of data collected by STCP-IITA in 2009 enabled us to draw the main conclusion: the impact of FFSs on cocoa yield is a reality. This effect is positive and statistically significant. It is estimated at about 97 kilograms per hectare by PSM method. This result is in line with that obtained by Godtland et al. (2004) who found that the participation in FFSs has the potential to significantly improve productivity in potato production in Peru. Furthermore, other results variables out of cocoa yield can explain the participation of farmer in FFSs. Those variables could be the quantity of fungicide and insecticide used and extension service. Given this conclusion, the first recommendation is to promote the FFSs in the area where there is no FFSs by highlighting agricultural extension service. The second recommendation is to improve the quality of training in Farmer Fields Schools in other to increase their impacts on cocoa yield

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Tables

Table 1: Statistics of data collected

Regions	Divisions	FFS	Non-FFS	Total
South-west	Meme	33	37	70
	Manyu	17	13	30
	Total 1	**50**	**50**	**100**
Centre	Nyong et Kéllé	26	25	51
	Mefou et Akono	25	25	50
	Total 2	**51**	**51**	**101**
Total		**101**	**100**	**201**

Source : IITA survey 2009

Table 2: Variables used in the model

Variable group	Variables	Nature des variables	Description of the variable
Household Characteristics	FFS	Dummy	1=Farmer has participated in Farmer Field Schools training field School; 0= Farmer did not participated in Farmer Field Schools training field School
	MALE	Dummy	1=Male; 0=Female
	HOUSEHOLD SIZE	Dummy	Number of persons living in the household
	FARMER AGE	Numeric and continuous	Farmer's Age
	FARMER EXPERIENCE	Numeric and continuous	Number of Years for farmer experience
	EDUCATION	Numeric and continuous	years of education the farmer had in total
	RADIO PROGRAM AWARE	Dummy	Farmer is aware of radio program providing information on agriculture
	MOBILE PHONE USE	Dummy	1= if farmer uses a mobile phone; 0=if farmer doesn't use a mobile phone
	AGRI- EXTENSION VISITS	Dummy	Number of agricultural extension official visits during the last 12 months
Farm Characteristics	FARM SIZE	Numeric and continuous	Farm Size in hectare
	FARM AGE	Numeric and continuous	Farm Age
	IMPROVED COCOA	Dummy	1=if farmer use improved planting material; 0=if farmer don't use improved planting material;
	DIVERSIFICATION	Numeric and continuous	Cocoa Diversification Index
	CAPITAL EQUIPMENT	Numeric and continuous	Mean cost of capital equipment during 2008 and 2009 in FCFA per hectare
	SHADE TREE	Numeric and continuous	Number of Shade tree per hectare
	REGION	Dummy	1=Centre; 0=South-West
Agricultural Practices	KNOWLEDGE TEST	Numeric and continuous	Knowledge Test of farmer concerning cocoa best practices
	TREE CUT	Dummy	1=Farmer has controlled cocoa farm shade by cutting tree; 0= Farmer did not controlled cocoa farm shade by cutting tree
	TREE PLANTED	Dummy	1= Farmer has controlled cocoa farm shade by planting tree; 0= Farmer did not controlled cocoa farm shade by planting tree
	CHUPONS REMOVE	Dummy	1 Farmer has removed Chupons in their farm during the last 12 months; 0= Farmer did not removed Chupons in their farm during the last 12 months;
	PESTICIDES COST 2009	Numeric and continuous	Mean Cost of Pesticide in 2009 in FCFA per hectare
	PESTICIDES APPLICATIONS	Numeric and continuous	Number. of Pesticides applications in the last 12 months
Output Variable	COCOA YIELD 2009	Numeric and continuous	Cocoa yield in 2009 in kilogram per hectare

Table 3: Data characteristics (Total sample in Cameroon)

Variable	Total sample (201 observations)				FFS participants (101 observations)				FFS non-participants (100 observations)				P-value
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	
FFS	0.5024	0.5012422	0	1	-	-	-	-	-	-	-	-	-
MALE	0.960199	0.1959795	0	1	0.9405941	0.2375619	0	1	0.98	0.1407053	0	1	0.9227
HOUSEHOLD SIZE	4.014925	2.490939	1	11	4.029703	2.491808	1	11	4	2.502524	1	11	0.4664
FARMER AGE	47.9801	14.99999	20	87	46.78218	14.0361	23	76	49.19	15.89339	20	87	0.8719
FARMER EXPERIENCE	17.32159	12.19086	0	66	17.93386	12.4892	2	66	16.7032	11.91268	0	50	0.2378
EDUCATION	7.724975	3.54251	0	17	8.039604	3.460985	0	17	7.4072	3.612461	0	17	0.1033
RADIO PROGRAM AWARE	0.373134	0.484845	0	1	0.4455446	0.4995047	0	1	0.3	0.4605662	0	1	0.0165**
MOBILE PHONE USE	0.527363	0.5004973	0	1	0.4851485	0.5022721	0	1	0.57	0.4975699	0	1	0.8848
AGRI- EXTENSION VISITS	0.203980	0.4039605	0	1	0.3762376	0.486857	0	1	0.03	0.1714466	0	1	0.0000***
FARM SIZE	2.37	1.759325	0.1	10.13	2.452178	1.756661	0.2	10.13	2.287	1.766947	0.1	10	0.2535
FARM AGE	32.06965	21.64631	2	107	33.26238	23.20459	2.5	107	30.865	19.99455	2	96	0.2169
IMPROVED COCOA	0.343283	0.4759907	0	1	0.3861386	0.4892913	0	1	0.3	0.4605662	0	1	0.1002
DIVERSIFICATION	0.938276	0.1243394	0.256	1	0.9315265	0.1298824	0.256	1	0.9452322	0.1186196	0.338	1	0.7808
CAPITAL EQUIPMENT	26932.35	44765.18	1281	457075	26636.81	47848.78	1818	457075	27230.85	41659.52	1281	347706.3	0.5373
SHADE TREE	204.2757	102.7535	33.33	644.4445	215.5363	111.9418	66.66	644.4445	192.9025	91.71851	33.33	587.6543	0.0593*
REGION	0.502487	0.5012422	0	1	0.5049505	0.5024692	0	1	0.5	0.5025189	0	1	0.4722
KNOWLEDGE TEST	0.487179	0.1637817	0	0.846153	0.501904	0.1680357	0	0.8461539	0.4723077	0.1588239	0	0.8461539	0.1005
TREE CUT	0.875621	0.3308364	0	1	0.9306931	0.2552421	0	1	0.82	0.3861229	0	1	0.0087***
TREE PLANTED	0.905472	0.2932915	0	1	0.9108911	0.2863218	0	1	0.9	0.3015113	0	1	0.3966
CHUPONS REMOVE	0.945273	0.2280133	0	1	0.970297	0.1706133	0	1	0.92	0.2726599	0	1	0.0591*
PESTICIDES COST 2009	58754.96	82770.29	0	725000	60969.48	94747.3	0	725000	56518.29	69010.57	0	429166.7	0.3520
PESTICIDES APPLICATIONS	12.41294	10.41171	0	52	11.85149	9.400411	0	48	12.98	11.3618	0	52	0.7782
COCOA YIELD 2008	435.8409	365.4548	26	2275	450.0143	400.548	29.55	2275	421.2245	326.8141	26	1482	0.2918
COCOA YIELD 2009	502.3411	348.2043	50	2068.182	538.4058	380.0171	75	2068.182	465.9158	310.4883	50	1406.25	0.0702*

Table 4: Probit estimation of FFS participation (Dependent Variable: FFS participation)

Variables	Total Sample
MALE	-0.658
	(0.647)
HOUSEHOLD SIZE	-0.0297
	(0.0528)
FARMER AGE	-0.0122
	(0.00856)
FARMER EXPERIENCE	0.0165
	(0.0105)
EDUCATION	0.0308
	(0.0354)
RADIO PROGRAM AWARE	0.398*
	(0.226)
MOBILE PHONE USE	-0.586**
	(0.233)
AGRI- EXTENSION VISITS	2.061***
	(0.377)
FARM SIZE	-0.0157
	(0.0732)
FARM AGE	0.00647
	(0.00587)
IMPROVED COCOA	0.123
	(0.235)
DIVERSIFICATION	-0.628
	(1.171)
CAPITAL EQUIPMENT	8.62e-07
	(3.47e-06)
SHADE TREE	0.00196*
	(0.00112)
REGION	0.286
	(0.352)
KNOWLEDGE TEST	0.669
	(0.669)
TREE CUT	0.616*
	(0.361)
TREE PLANTED	0.506
	(0.384)
CHUPONS REMOVE	0.497
	(0.493)

PESTICIDES COST 2009	1.33e-06
	(1.77e-06)
PESTICIDES APPLICATION	-0.0210
	(0.0129)
COCOA YIELD 2008	5.38e-05
	(0.000380)
CONSTANT	-1.190
	(1.606)
OBSERVATIONS	195

***Significant at 1% level; **Significant at 5% level; Standard errors is in parentheses

Table 5: Balancing test of samples

Variables	Unmatched sample			Kernel-based matching			5 nearest neighbors matching		
	Means		P-value	Means		P-value	Means		P-value
	Treated	Control		Treated	Control		Treated	Control	
MALE	0.93939	0.97917	0.163	0.96	0.98582	0.333	0.96	0.98582	0.333
HOUSEHOLD SIZE	4.0101	4.0208	0.976	3.92	3.997	0.860	3.92	3.997	0.860
FARMER AGE	46.616	49.021	0,290	47	46.352	0.794	47	46.352	0.794
FARMER EXPERIENCE	18.094	16.857	0.482	18.751	19.459	0.742	18.751	19.459	0.742
EDUCATION	7.9798	7.4033	0.255	7.7333	7.6679	0.911	7.7333	7.6679	0.911
RADIO PROGRAM AWARE	0.45455	0.30208	0.028**	0.42667	0.40887	0.827	0.42667	0.40887	0.827
MOBILE PHONE USE	0.47475	0.5625	0.222	0.45333	0.30969	0.071*	0.45333	0.30969	0.071*
AGRI- EXTENSION VISITS	0.37374	0.03125	0.000***	0.18667	0.14833	0.533	0.18667	0.14833	0.533
FARM SIZE	2.4795	2.3313	0.561	2.4743	2.5278	0.871	2.4743	2.5278	0.871
FARM AGE	33.793	30.87	0.351	32.887	31.765	0.748	32.887	31.765	0.748
IMPROVED COCOA	0.39394	0.29167	0.134	0.36	0.38381	0.765	0.36	0.38381	0.765
DIVERSIFICATION	0.94279	0.95484	0.404	0.93959	0.93562	0.829	0.93959	0.93562	0.829
CAPITAL EQUIPMENT	26690	27352	0.919	29071	23590	0.435	29071	23590	0.435
SHADE TREE	213.27	192.03	0.148	216.1	218.59	0.893	216.1	218.59	0.893
REGION	0.50505	0.47917	0.719	0.49333	0.50279	0.909	0.49333	0.50279	0.909
KNOWLEDGE TEST	0.50117	0.47196	0.211	0.49128	0.51764	0.352	0.49128	0.51764	0.352
TREE CUT	0.92929	0.82292	0.024**	0.92	0.93537	0.719	0.92	0.93537	0.719
TREE PLANTED	0.90909	0.89583	0.756	0.89333	0.86752	0.629	0.89333	0.86752	0.629
CHUPONS REMOVE	0.9697	0.91667	0.110	0.96	0.9376	0.537	0.96	0.9376	0.537
PESTICIDES COST 2009	61603	57948	0.762	65552	4918	0.251	65552	4918	0.251
PESTICIDES APPLICATIONS	11.646	12.938	0.380	12.093	11.004	0.496	12.093	11.004	0.496

Table 6: Average effect of FFS on cocoa yield after two stapes replication
(Outcome variable: cocoa yield 2009)

	Kernel-based matching	**5 nearest neighbors matching**
ATT	96.61011*	108.1843
Std. error	52.73108	70.05896
Number of observations of Treated group	99 (24)	99 (24)
Number of observations of control group	96(0)	96(0)
Total number of observations	195(24)	195(24)

Note: Observations in parentheses were not used in the estimate due to the common support condition stratified. Bootstrap with 100 replications are used to estimate the standard errors, *significant at 10% level.

Figure

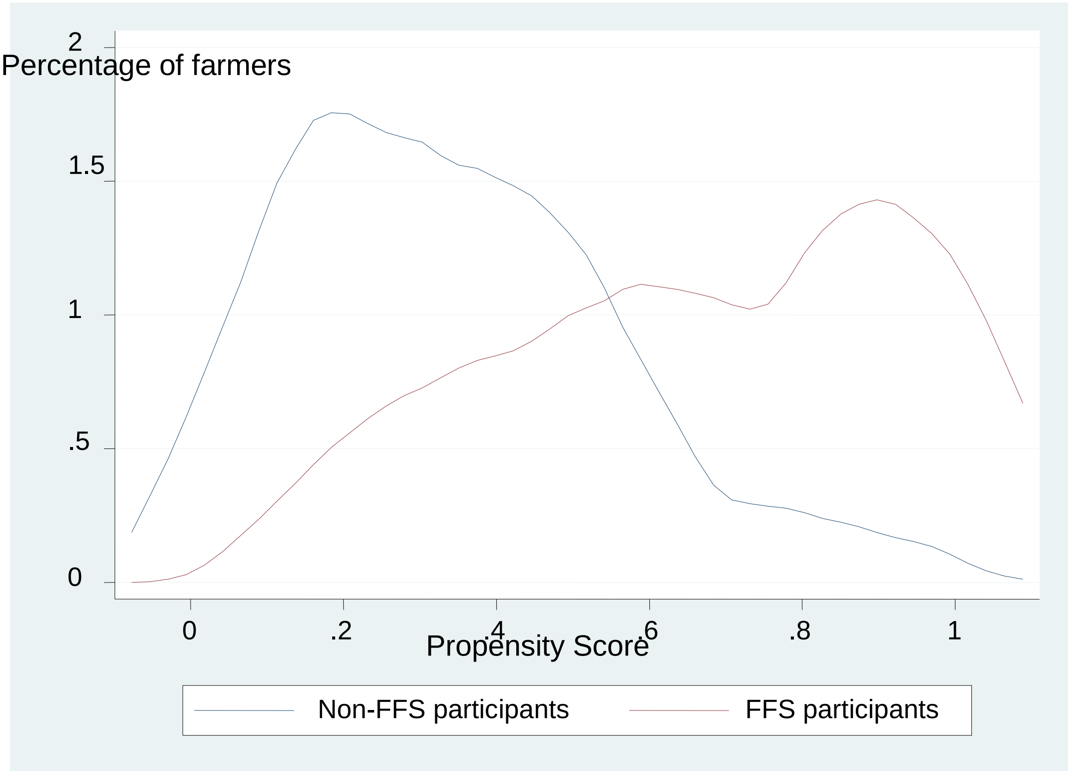

Figure1: Propensity scores distribution among treatment and control groups