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Research Paper

Does Participation in Farmer Field School Extension Program Improve Crop Yields? Evidence from Smallholder Tea Production Systems in Kenya

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Abstract

Agricultural Extension services are among the most important rural services in developing countries. The services are considered to be a key driver of technological change and productivity growth in agriculture. In Kenya, like in the rest of the developing economies, agricultural extension has largely been delivered through supply–driven approaches. Due to perceived low impact of agricultural extension, the country is implementing the National Extension Policy (NEP) which advocates for demand–driven extension and participation of other players. Using the case of the smallholder tea sub-sector, this paper examines the effects the FFS extension on tea crop yields in Kenya. The FFS system uses participatory approaches including the demonstration of best sustainable practices in the farms and farmers learn by doing. Data for the study was collected from a sample of 525 farm households in Western Kenya using a multi stage random sampling procedure and analyzed using the propensity score matching (PSM) model which controls for self-selection endogeneity. The results show that participation in FFS extension increases annual tea yields by an average of 471.70 kgs per acre (p=0.009) while the farmer–funded train and visit system has no influence on crop yields. A part from showing the contribution of FFS to crop yields, the paper demonstrates that the supply–driven extension models including T&V are necessary to stimulate demand in the initial stages of implementing the FFS models. Based on the findings, investments to enhance FFS access among smallholder farmers are recommended.

Keywords:
FFS extension, train and visit, tea productivity, demand–driven extension services, propensity score matching, self-selection endogeneity

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INTRODUCTION

The agricultural sector in developing countries is facing unprecedented changes and challenges, including climate change, land and water constraints and changing markets and consumption patterns. The knowledge intensive nature of the sector is therefore more evident now than ever before. In response to the need to respond to the emerging challenges, the design of agricultural extension programs has been the subject of much debate. At the heart of the debate are questions regarding the choice of extension models that can work 'best' for smallholder farmers (Bitzer et al. 2016; Ektear et al., 2017; Klerkxet al., 2013; Nettleet al., 2017; Swanson & Rajalahti, 2010). A particular issue emerging from scholarly and practitioner domains relates to the effectiveness of two dominant approaches to extension services—Training and Visit (T&V) and Farmer Field Schools (FFS). The T&V approach relies on the "top-down" extension of technical information, with specialists and field staff transferring knowledge to "contact farmers" in villages, who in turn are responsible for diffusing knowledge into the local community (Davis, 2008; Musa et al. 2013). The main weaknesses of the system relate to the fact that its supply driven and has been blamed to be non-responsive to the farmers needs and interests. Additionally, T&V suffers from sustainability issues due to the high cost of implementation (Musa et al., 2013). Despite facing immense criticism, various variants of the T&V system are still being implemented in different contexts in the developing world.

As a response to the weaknesses of T&V system, FFS was developed as a "bottom-up" approach to extension with a focus on improving the problem-solving capacity of farmers through participatory, experiential, and reflective learning (Anderson & Feder, 2007). FFS as an approach provides a platform for farmers to meet regularly in groups to study, test and adapt farming practices to their local conditions (Glendenninget et al., 2010). The approach differs significantly from mainstream extension practice by its emphasis on group peer learning, facilitation rather than a teaching pedagogy and local innovation processes rather than technological message transfer (Friis-Hansen et al., 2012).

Although the FFS approach is being tried and scaled up, its cost-effectiveness and ability to ensure sustained increase in productivity and impact of the approach is still a subject of ongoing debate (Birner et al., 2009; Davis et al., 2012; Larsen & Lilleør, 2014). While some studies find positive impacts of FFS on agricultural yields, others do not (for example, Abdullah et al., 2014; Davis et al., 2012; Feder et al., 2004; Friis-Hansen et al., 2012). A major drawback of most previous studies is that they do not appropriately control for potential differences between FFS participants and farmers in the comparison group, making it difficult to assign a causal attribution to the estimates. The problem is that participants and non-participants may still exhibit differences in yields even in the absence of participation, which renders causal interpretation of the differences difficult (Verbeek, 2012). Additionally, many previous studies on FFS, do not take into account the fact that there are many instances where FFS programs are implemented alongside the T&V system. The implication is that they are therefore not able to account for the influence of the T&V on FFS performance.

Another weakness is that many previous studies are based on qualitative methods (Birner & Anderson, 2007; Diab, 2015; Feder et al., 2004; Friis-Hansen et al., 2012; Mfitumukiza et al., 2017), which despite providing in-depth understanding on how extension approach works, fails to provide robust empirical evidence on quantitative indicators of impact such as yields and incomes. In light of the foregoing, many questions about when, where, and how FFSs should be implemented continue to trouble extension actors in the developing countries.

This article uses a treatment effects framework which controls for placement bias and a unique data set to assess the impact of FFS extension on smallholder tea yields in Kenya. The data was collected in western Kenya where the Kenya Tea Development Agency (KTDA), one of the largest smallholder schemes in world (Mbeche & Dorward, 2014) is implementing an integrated extension model that combines both FFS and elements of the T&V system. The data set allowed us to simultaneously compare the impacts of FFS and T&V, a contribution that has not been considered in most previous studies. The paper shows that participation in FFS is important for tea yields and further demonstrates that while the T&V system appears not to have effects on tea yields, it is important in enhancing participation in FFS. Our extension to include the determinants of FFS participation in the analysis was motivated by low levels of enrolment in FFS by farmers despite scale up efforts by KTDA. Drawing from the results, the paper reflects on the circumstances under which the two extension systems become complimentary rather than substitutes.

The paper proceeds as follows. Section two describes context of FFS implementation in the tea subsector in Kenya. Section three presents the theoretical and empirical models applied in the analysis of impact, while section four presents the data and variables. Section five presents the results and discussions and section six concludes with reflections on policy implications.

FFS implementation in smallholder tea subsector in Kenya

Tea plays an important role in Kenya's socio-economic development. The industry is a leading foreign exchange earner and offers livelihood to over 0.6 million smallholder farmers (Mbeche & Dorward, 2014). Despite its critical role in the economy, productivity has remained low characterized by stagnation and decline (Ateka et al., 2018). The unimpressive trend reflects existence of production constraints as evidenced by huge yield differentials between the smallholder and the plantation tea subsectors (Figure 1). The better performance of the plantation subsector is often attributed to the presence of appropriate systems for technology transfer including capacity for in-house research. Enhancing yields is an essential factor of growth in the subsector since tea cultivation requires high investment and involves very high switching costs.

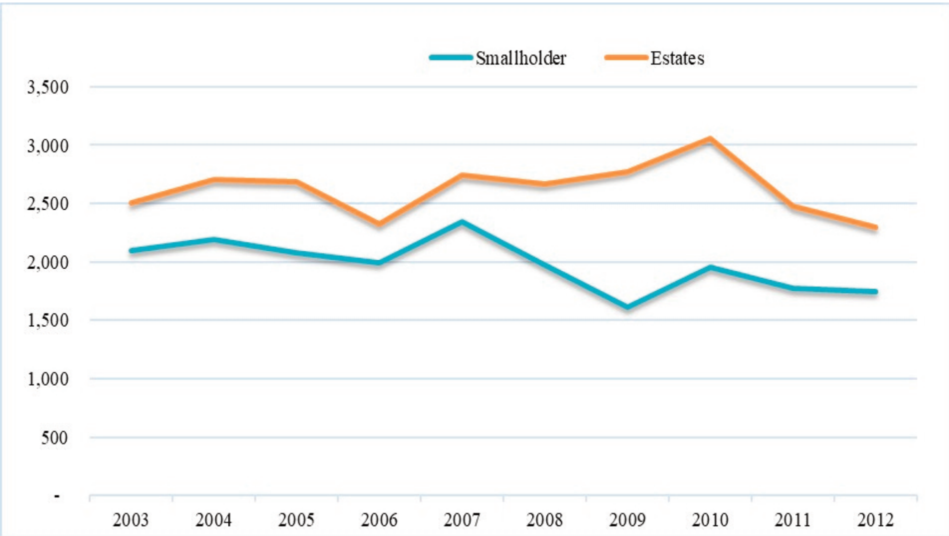

Figure 1. Productivity trends (2003-2012) in Kenya

In response to the productivity downturns, KTDA in the year 2006 and with support from the DFID and other stakeholders started to pilot the FFS extension approach as a key intervention. After successful trials and piloting, FFS has been embedded within the KTDA extension strategy and is being implemented to compliment a privatized and farmer–funded T&V system which was introduced in the tea sector in the late 1990s as part of the structural adjustment reforms. The privatized T&V system incorporated a number of performance evaluation elements based on negotiated key performance indicators that include among others; a specified number of farm visits, farmer meetings, demonstrations and field days. Despite the initial optimism, the privatized extension system like its predecessor (the public funded T&V system) was characterized by challenges in meeting farmers' expectations (Mose et al., 2016). Implementation of the new system that incorporates FFS with some elements of the T&V is underway (Mose et al., 2016). But despite efforts to scaleup, participation in FFS among the tea farmers has remained low. Key informant interviews with KTDA staff indicated that FFS enrollment was about 10 percent by 2016.

The KTDA FFS model focuses on training farmers on sustainable practices through the field schools which are units where tea farmers are trained to practice sustainable agricultural practices such as best-practices in tea husbandry, soil fertility management, pesticide use and protection of bio-diversity. The approach empowers farmers to be their own technical experts and to adapt potentially applicable technologies to their own particular conditions by enhancing farmers knowledge (technical and socio–economic), decision making and problem-solving skills, and stimulating collective action (Feder et al., 2004). Farmers trained in sustainable agricultural practices are expected to train others to achieve the required husbandry standards (Friis-Hansen et al., 2012; Glendenning, et al., 2010).

METHODOLOGY

The theoretical approach and empirical models

The analysis of impact in this paper is assessed within a treatment effects framework. This refers to the causal effect of a binary variable on an outcome variable of policy interest (Cameron &Trivedi, 2005) which in the present situation is the effect of participating in FFS on tea yields. To analyze the effects two potential outcomes; the outcome with treatment, and the outcome without treatment can be delineated. Using these outcomes, the average treatment effects (ATE) and the average treatment effects on the treated (ATET) can be derived as shown in equation 2.1 and 2.2.

$$ATE= E(Y_{1i} - Y_{0i}|X_i) \qquad (1)$$

$$ATET= E(Y_{1i} - Y_{0i}|X_i; D_i=1) \qquad (2)$$

where, is a vector of household characteristics and denotes the household participation status in an extension program. Unlike ATE which simply describes the expected effect of treatment for an arbitrary household with characteristics; ATET measures the mean effect of those who actually participated in the program. The measure is therefore more relevant for evaluating the treatment effects of a program and is achieved by comparing the performance of the participating households with the outcome the same households would have achieved without participation (Verbeek, 2012).

A critical issue in the estimation of ATET is how households are assigned into the treatment program. Under random assignment, as is in experimental or quasi experimental studies, ATET can be obtained as the difference in the average outcomes between the participants and non-participants as shown in equation 2.3;

$$ATET = \frac{1}{N_P}\sum_{i=1}^{N} Y_{1i} - \frac{1}{N_{PN}}\sum_{i=1}^{N} Y_{0i} \qquad (3)$$

The approach is however inappropriate for the estimation of ATET using cross sectional data since the assumption of random assignment does not hold. The problem is that the estimates of ATET based on equation 2.3 are be subject to selection or placement biases which render the estimates causally un-interpretable (Cameron & Trivedi, 2005; Clougherty & Duso, 2015). The problem arises when the selection process of the agents being analysed represents an excluded variable that manifests in the error term and correlates with the endogenous choice and outcome variable (Antonakis et al., 2010). In the face of the potential biases, the Propensity Score Matching (PSM) model which provides a non– biased measure of impact, under assumptions of conditional mean independence and common support was applied. The first assumption implies that the distribution of potential outcomes for the units under analysis is the same regardless of their treatment status. The latter assumes that all the treated observations have a counterpart in the non-treated group (Verbeek, 2012).

The PSM procedure begins with the estimation of propensity scores (PS) which refers to the probability of treatment given a set of covariates. The calculated scores are then used to match the respondents into the two treatment groups and was modelled using equation 2.4

$$P(S)_i = Pri\ (D_i=1/X_i) \quad (4)$$

where $Pri\ (D_i=1/X_i)$ represents the conditional probability of an observation being assigned into the treatment given its observed characteristics. In the study we followed the prevailing trends regarding choice of variables for estimating PS, choice of matching algorithms (Khandker et al. 2010), and matching quality analysis (Caliendo and Kopeinig 2008; Rosenbaum & Rubin 1983).

After matching, ATET is estimated by calculating the difference in outcome between the treated and the non – treated group as shown in equation 2.5.

$$ATET=E(Y_{1i}/D=1) - E(Y_{0i}/\ D=1) \quad (5)$$

where $E(Y_{1i}/D=1)$ is conditional mean of the outcome for the treated contingent on participation in the treatment and $E(Y_{0i}/\ D=1)$ is the conditional mean of the outcome for the non-treated conditional on participation.

Data and variables

Data for the study was collected from a cross sectional survey of 525 smallholder tea farming households drawn from Nyamira and Bomet counties in western Kenya. The data was collected between 2015 and 2016 using a multi-stage random sampling procedure. The survey collected data on various farm level characteristics, household demographic, socio economic characteristics and institutional variables. The selection of the variables was based on previous impact studies and the theory of farm household decision-behavior in developing countries (de Janvry et al., 1991; Fealy & Ahmadpour, 2017). This data set is considered unique since it was drawn from respondents who had access to an integrated system of extension that combined both the T&V and FFS extension models. This feature allowed comparison of the performance of the two extension systems. The definition and measurement of variables included in the analysis are outlined in Table 1.

EMPIRICAL RESULTS AND DISCUSSIONS

Descriptive summaries

The results of the descriptive analysis for the continuous variables are presented in Table 2 while those for the discrete covariates are summarized in Table3. The descriptive analysis includes the comparison of means between the FFS participants and non-participants for the outcome variable (yields) and the various covariates of FFS participation. The results (Table 2) show that the participating households had higher tea yields than the non-participants. The annual tea produc-

Table 1

Definition and Measurement of Variables

Variable	Definition and measurement
Extension services (FFS)	This is participation of the household in the farmer field school (FFS) program measured using dummies; where 1 represents participation in FFS and 0 otherwise.
Education	The education status of the household head measured in terms of the highest level of education attained (1= primary, 2 = secondary, 3 = tertiary 4= university).
Labour structure	The proportion of family labour utilised in tea production.
Age of farmer	The age of the household head measured in years.
Gender	This is defined in terms of the gender of the household head and was measured using dummies; where 1 represents a male headed household and 0 otherwise.
T&V Extension	This is the level of extension services received by the farmer measured in terms of the number of visits to/by the extension agent/year.
Household assets	The value of selected household assets measured in Kenya shillings.
Credit	Describes receipt of borrowed money for agricultural activities measured using dummies (1= if the household had borrowed and 0 otherwise).
Transaction costs	Measured using a proxy, the distance to nearest market in kilometres.
County dummy	The variable accounted for the effects associated with regional differences and was measured using county dummies (1 = Bomet county, 0 = Nyamira county).
Age of the tea farm	The age of the tea farm measured in number of years since current bushes were planted.
Per capita expenditure	The per capita amount of money spent on the purchase of a basket of selected household necessities per year measured in Kenya shillings.
ATMC participation	This is participation of the household in an ATMC. The variable was measured using dummies; where 1 represents participation in ATMC and 0 otherwise.

tivity was 2746 kgs per acre in the combined sample, compared to 2461 kgs for the non-participating households and 3001 kgs per acre for the participants. While the yield difference provides a hint on the probable direction on the influence of FFS on productivity, the simple comparison of averages has no causal interpretation, given that the decision to participate in the FFS program is potentially endogenous. The reason is that the differences in tea yields may not be the result of participation in FFS, but instead might be due to other factors, such as differences in other observed and unobserved characteristics. A causal attribution would therefore be misleading since the participants and non-participants may still exhibit differences in yields even in the absence of participation, rendering causal interpretation of the difference difficult (Verbeek, 2012).

As shown in Table 2, the farms of the FFS participants had higher fertilizer application rates; were using less labour per unit area, proportionately more family labour relative to hired labour and comparatively younger tea bushes than the farms of non-participants. The age of the tea farm is an important variable in tea production since aging tea plantations are associated with decline in tea productivity (Ateka et al., 2018). The average age of tea bushes in the sample was 27 years. Comparatively, the mean age was 28.5 years for non-participating households and 25.7 years for the participants. Additionally, participating farmers were relatively younger than the non-participants. The average age of the household head among the non-participants was 50.5 years compared to 48.0 years for the participants. The differences in the other continuous variables including distance from the farm to the nearest market,

Table 2
Summary Statistics for the Continous Variables

	Non -participants (n =248)	Participants (n =277)	Combined (n =525)	t	*p*-value
Yield	2461	3001.04	2475.9	3.01**	0.003
Fertilizer (bags)	4.28	4.88	4.6	1.78	0.08
Labour/acre	175.45	153.52	163.88	1.82	0.07
labour structure	51.6	64.03	58.16	3.15**	0.002
Age of farm (years)	28.5	25.7	27.0	2.02*	0.032
Farm size (hectare)	1.34	1.33	1.34	0.1	0.922
Distance (km)	2.86	2.94	2.9	0.33	0.74
Household size (percent)	6.47	6.16	6.31	1.24	0.21
Age of farmer (years)	50.5	48.0	49.2	1.96	0.05
Assets (Kenya Shillings)	112,935.7	102,077.1	107,245.6	1.23	0.22
Per capita expenditure	42,548.2	42,752.5	42,658.5	0.073	0.94

**$p<0.01$ and *$p<0.05$

per-capita expenditure and household assets were not statistically significant. The per capita expenditure and household assets were included in the analysis to represent the household stock of capital which is thought to be an important determinant of economic outcomes and household behavior. It is expected that households with higher capital stock, would have a higher likelihood to participate in FFS.

Among the discrete variables, the descriptive analysis shows that the FFS participating households had generally higher levels of education than the non-participants. As shown in Table 3, the FFS participants had proportionately higher levels of education (secondary, tertiary and university) compared to the non-participants. In terms of credit use, the results show that the proportion of households that had used credit among the non-participants was 58.1 percent compared to 79.1 percent for the participants. The lower levels of credit utilization among the non-participating households would mean that they were either more constrained in accessing credit or were more averse to its use. Additionally, the descriptive results show that proportion of households who had access to the T&V extension was higher (87.7%) among the participants compared to the non-participants (75.4%).

Determinants of household participation in FFS

This section, discusses the results of the probit model results presented in Table 4. The variables in the model included various household demographic characteristics (gender, age of farmer, education, household labour structure), farm level characteristics (farm size, age of farm and distance to the nearest market), the household economic characteristic (household assets and per capita expenditure) and institutional variables (access to T&V extension and credit).

As shown in Table 4, the coefficient of the age of the household head was statistically significant at standard levels. The coefficient was negative suggesting that an increase in the age of the farmer is associated with a decline in the probability of participation in FFS. This finding could be attributed to the fact that older farmers are more likely to be reluctant to accept new information and

Table 3

Summary Statistics for the Discrete Variables

Variable	Indicator	Non-participants		Participants		Combined		*p*-value
		Frequency	%	Frequency	%	Frequency	%	
Gender	0	46	18.5	37	13.4	83	15.8	0.104
	1	202	81.5	240	86.6	442	84.2	
Education	1	131	52.8	107	38.6	238	45.3	0.011
	2	89	35.9	122	44.0	211	40.2	0.057
	3	20	8.1	30	10.8	50	9.5	0.281
	4	8	3.2	18	6.5	26	5.0	0.085
Credit	0	104	41.9	58	20.9	162	30.9	0.000
	1	144	58.1	219	79.1	363	69.1	
T&V extension	0	61	24.6	34	12.3	95	18.1	0.0003
	1	187	75.4	243	87.7	430	81.9	
Market channel	0	151	60.9	183	66.1	334	63.6	0.220
	1	97	39.1	94	33.9	191	36.4	

Table 4

Marginal Effects of Determinants of FFS participation

Dependent Variable Participation in FFS Extension				
Variable	**Coefficient**	**Std. Err.**	**Z score**	***p*- value**
Gender	0.029	0.07	0.43	0.669
Age of head	-0.023*	0.01	-1.66*	0.096
Square of age of head	0.000*	0.00	1.85*	0.064
Education (Primary)	-0.279**	0.13	-2.15**	0.031
Education (secondary)	-0.185	0.13	-1.40	0.161
Education (Tertiary)	-0.109	0.15	-0.73	0.463
labour structure	0.168***	0.06	2.88**	0.004
Age of farm (years)	0.018*	0.01	1.68*	0.094
Square of age of farm (h)	0.000*	0.00	-1.87	0.062
Transaction costs	0.006	0.01	0.68	0.497
Household assets	0.000	0.00	-0.75	0.456
Per-capita expenditure	0.000	0.00	-0.19	0.846
market channels	0.133***	0.05	2.67***	0.007
T & V Extension	0.214***	0.06	3.60***	0.000
Credit	0.256***	0.05	5.06***	0.000

*** $p<0.01$, ** $p<0.05$ and * $p<0.1$

technologies than the younger farmers. In the study, a quadratic term, the square of the age of the household head was introduced to capture the influence of any non-linearities between the relationship between the age of the household head and the participation in FFS. This was necessary since it is expected that FFS participation would increase to a peak, as age of the farmer increases then declines as the farmer gets old or attains retirement age. Although the coefficient of the quadratic term was positive and statistically significant, the value of its magnitude was zero which suggests that the influence of age related non-linearities may not have important influence on the household decision to participate in FFS. The finding that the age of the household head is negatively linked with the propensity of participation in FFS is consistent with a study by Asres et al. (2013) which found that the age of household head was negatively associated the probability of joining an extension program.

On education, the coefficient of the primary education dummy was negative and statistically significant. The Education level of household head was included as a proxy for human capital and therefore the ability to learn and apply technologies in tea production. The results confirm the expectation that low levels of human capital (education) would be associated with the likelihood of non-participation in the FFS program. The observation is consistent with the assertion that farmers with higher levels of education are more likely to be the early adopters of agricultural innovations than those with less education (Gebregziabher et al., 2011). The finding is also consistent with Cai et al. (2016) who found that higher educational achievement and more wealth were associated with attendance of more FFS sessions. The result is also in line with a preference by the proponents of FFS to target more highly educated farmers, those with greater land endowments, younger farmers and women and those with relatively low opportunity costs of labour (Waddington et al., 2014). It is however important to note that the FFS program can be used to target low-education groups, since the methodology, demonstration sites, experiential learning methods, group approaches, and other factors can allow people with minimal education to participate and benefit (Butt et al., 2015).

The results of the binary model also show that an increase in the share of family labour applied in tea production is associated with an increase in probability of participation in the FFS program. The finding would be attributed to the fact that labour is an important variable in tea production. Additionally, this would be due to the presence of imperfections in labour markets which make family and hired labour to be imperfect substitutes. The reason is that hired labour tends to be more expensive than family labour due to additional transaction costs of search and screenings (Kiani, 2008). Additionally, the higher transaction costs may be associated with the additional monitoring costs since work effort in a tea farm may not be completely observable, verifiable and enforceable (Ateka et al., 2018). The significance of labour in tea farming derives from the view that when labour constraints are binding, farmers may fail to carry out the required tea husbandry practices at the optimum time or lack the time to attend educational programs.

With regard to the farm level characteristics, the coefficient for age of the farm was weakly significant. This means that a farmer with an older tea farm has a higher probability of participating in the FFS program than a farmer with younger tea. While an a priori explanation for the positive association is less obvious, the relationship could be related to the farmer's experience in tea farming. This is because experience broadens the farmer's social network where more market information can be acquired leading to the establishment of more networks and linkages (Shilpi & Umali-Deininger, 2007). The coefficient for the quadratic term for age of the farm was significant but with zero magnitude hence refuting the importance of non-linearities between age of the farm and participation in FFS. The observation is however inconsistent with Cai (2016) who found that younger and less experienced farmers were more likely to participate in FFS.

As shown in Table 4, the coefficients of the variables included in the analysis to capture the influence of institutional arrangements

(T&V extension, ATMC participation and credit) were positive and statistically significant. The results therefore underscore and confirm the fact that the presence of appropriate institutional arrangements including the access to input and output markets is a key determinant of farmers' participation in the FFS program. This is for instance explained by the observation that borrowing relaxes liquidity constraints that households would face in implementing the new technologies promoted by the FFS curriculum.

The other important observation is that the T&V extension has important influence on FFS participation, therefore suggesting existence of complementarities between FFS and other extension systems. This is in light of the low coverage of extension services in developing countries, which necessitates the need to combine FFS with other faster approaches for diffusion of information and technologies (Bentley et al., 2015). The implication is that the supply–driven extension models including T&V are necessary to stimulate demand in the initial stages of implementing the FFS models. This observation is also important in light of previous studies showing evidence of alternatives learning methods having greater influence on the uptake of disseminated technologies than FFS. An example is Ongachi et al. (2017) who found that Video Mediated Learning (VML) was more effective in enhancing the farmers' learning and capability for uptake of new agricultural innovations than the FFS training.

Effects of FFS extension on crop yields

After estimation of the PS and the analysis of the determinants of FFS participation, matching of the participant households with the non-participants was implemented using the nearest neighbor matching (NNM) algorithm. In NNM, each FFS participant is matched to closest non-participant using the estimated PS. After the matching process, the quality of the matching was tested using two procedures that aimed to assess whether the overlap or common support condition which is necessary in PSM was satisfied in the data (Asres et al., 2013). This condition assumes that some randomness is required in order to guarantee that farm households with identical characteristics can be observed in both states (Heckman et al., 1999). The first procedure involved checking the density distribution of the propensity scores after the matching process. A visual inspection of the density distribution shown in Figure A.1 (in the appendix) indicates that there was substantial overlap in the distribution of propensity scores for both the FFS participating and the non-participating households.

The second procedure involved testing the hypothesis that differences in the means of the covariates for both groups were not significant (after matching). Insignificant differences imply that the matching is successful in balancing the distribution of relevant variables in both groups. The results of the balancing test are reported in Table 6 in the appendix. The results show there were no significant differences in the means of the covariates for both for the FFS participants and non-participants after matching. This suggests that the specification of the PS was fairly successful in balancing the distribution of covariates between the two matched groups. We therefore conclude that the PSM process was suitable for the estimation of the participation effects and the common support condition was fulfilled.

The effect of FFS participation on TE was calculated as the difference in average yields between the two matched and the results are reported as ATET in Table 5.

The results in Table 5 show that the coefficient for ATET was 471.7 which suggest that participation in FFS had a positive and statistically significant effect on yields. The coefficient for the conventional T&V extension was not statistically significant at standard levels. This suggests that there was no statistically significant difference in yields between farmers who accessed the T&V extension and those that that did not. This is despite the fact more households in the sample had accessed

Table 5
The Effects of FFS Participation from PSM

Estimator	Outcome	Effect	Coefficient	AI Robust SE[1]	Z value	*p*-value
FFS	Yield per acre	ATET	**471.7**	**181.03**	**2.61*** **	**0.009**
T&V Extension	Yield per acre	ATET	350.901	240.5872	1.46	0.145

*** $p<0.01$
[1] AI robust standard errors are used to generate heteroskedastic –robust variance estimators to correct for potential heteroskedasticity (Abadie & Imbens, 2002).

extension education from T&V system than the new FFS extension. The results are consistent with expectation since FFS is a new approach to extension which was adopted by the tea sector to address the weaknesses of the conventional T&V approach (Mose et al., 2016). The attractiveness of FFS is associated with its use of participatory adult leaning approaches and emphasis on stronger linkages between research, extension and farmer experimentation. The finding is consistent with evidence showing that that the FFS approach adds to the traditional transfer-of-technology approach in imparting knowledge on good agricultural practices (Ongachi et al., 2017). The finding has equally important implications in light of findings showing that agricultural information rather than the farmers' personal and socioeconomic characteristics is key in maximizing uptake of new agricultural interventions (Cai et al., 2016; Ongachi et al., 2017).

CONCLUSIONS AND POLICY IMPLICATIONS

In this article, we show the causal effect of participating in FFS-extension on farm yields among smallholder tea farmers in Kenya. We applied the PSM model and a variety of matching quality analyses which indicated that our matching procedures were effective in balancing the covariates. The study used a unique data set collected to allow for impact evaluation and comparison of two extension approaches. One key finding relates to the farmers' decision to participate in the FFS program. The result reveals a fundamental observation that while the T&V extension system appears not to have an impact on tea yields, its access is important for FFS participation. This may be linked to the ability of T&V to reach many farmers and its personalized attention to specific needs (Jafry et al., 2014). The implication is that for the demand-driven extension systems to take root in practice, farmers must be empowered to develop their capacity to articulate their demands. This is important in light of the low coverage of extension services in developing countries and evidence showing that combining FFS with other methods such video mediated learning and radio and television-based approaches greatly influences uptake of technologies and innovations (Ongachi et al., 2017; Waddington et al., 2014). The Findings of the study also show that access to credit and presence of appropriate arrangements for tea marketing are important determinants of FFS participation. We therefore recommend that institutional actors involved in FFS should consider other complementarities that address the farmers' needs in the design and implementation of the FFS programme (Waddington et al., 2014).

Further, the results show that participation in the FFS program has a positive impact on tea productivity. By providing evidence on the impact of FFS and the complimentary role of the T&V, we contribute towards the renewed discussion regarding the design of appropriate extension models for smallholder farmers in the developing world. Apart from showing that FFS is an important pathway for enhancing smallholder crop yields, we also show that scale up and success of the demand-driven extension models require mechanisms that develop and enhance the capacity of smallholder farmers to articulate their extension demands and learning needs (Sulaiman & Blum, 2016). Putting in place such mechanisms is therefore an important prerequisite for the success of FFS.

Based on the results, we recommend the deepening and up scaling of the FFS program so as to enlist more tea farmers into the program. This should be should be reinforced with awareness campaigns to sensitize farmers about the enrolment and benefits of the FFS curriculum. We further recommend that the design of the FFS program should consider complimentary packages including those intended to correct for market and other institutional failures.

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APPENDIX

Table 6
Balancing Test of Matched Groups (PSM)

Variable	Mean		t-value	*p*-value
	participants	non participants		
Gender	0.86	0.79	2.09	0.37
Age of head	48.24	48.55	-0.25	0.805
Education (Primary)	0.4	0.44	0.89	0.38
Education (secondary)	0.45	0.42	0.62	0.54
Education (Tertiary)	0.1	0.07	1.26	0.21
Education (Education)	0.05	0.07	0.89	0.38
labour structure	0.68	0.63	0.7	0.48
Age of farm	21.03	21.56	0.44	0.66
farm size	1.27	1.33	0.64	0.522
Transaction costs	2.96	3.13	0.7	0.48
Household assets	100,000	110,000	0.67	0.506
Per-capita expenditure	40433	37275	1.32	0.188
market channels	0.34	0.28	1.61	0.107
T & V Extension	0.88	0.89	0.41	0.68
Credit	0.78	0.77	0.32	0.75

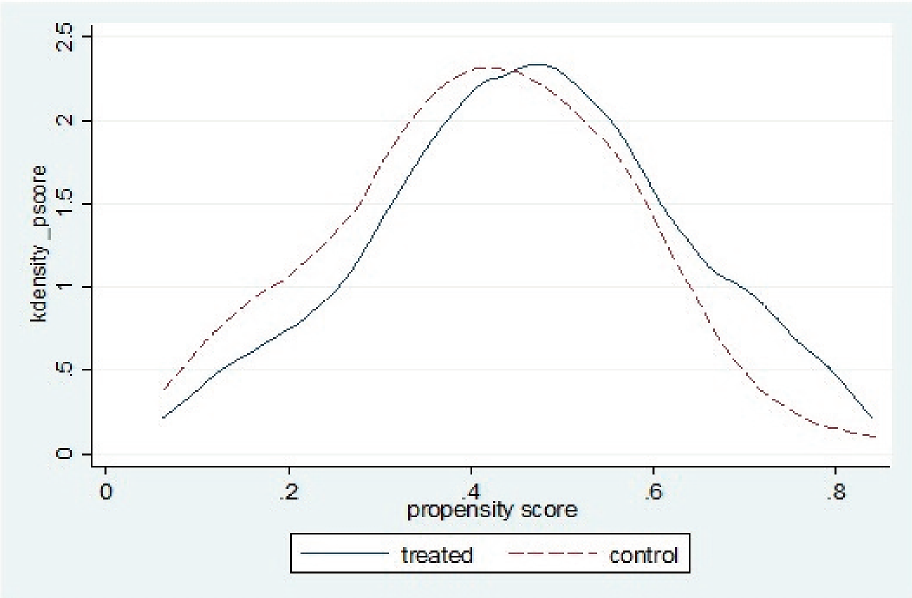

Figure A.1: Distribution of propensity scores for the participants and non-participants after matching

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