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Research article

Training at farmers training centers and its impact on crop productivity and households' income in Ethiopia: A propensity score matching (PSM) analysis

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ABSTRACT

The creation and expansion of training and extension networks for rural households are indispensable to develop and improve skills and to increase productivity and income-generating capabilities. In this line, Ethiopia has established farmers/pastoralists training centers (F/PTCs) since 2002 aimed at providing a multitude of services to farmers at the grassroots level. One of these services is the provision of training. The purpose of this study, therefore, is to assess the impact of training on crop productivity and households' income in the study area. Cross-sectional data were collected from April to June 2020 from 362 and 373 sample respondents involved in wheat (Triticum aestivum) and maize (Zea mays) production in the 2018/19 main cropping season, respectively. The mixed-methods research approach was used for the study. The quantitative data were collected through a semi-structured interview schedule from the respondents. The qualitative data were also collected by interviewing key informants and conducting focus group discussions. The propensity score matching (PSM) model was applied to analyze the impact of training on the aforesaid outcome variables. About 87% of the sample households were engaged in both wheat and maize production in the study area. The PSM results found indicate that trainees increased their wheat and maize yield by 860.16 (26.66%) and 301.56 (10.10%) kg ha-1, respectively. They also earned a net annual income of 7,490 (19.64%) Ethiopian birr ha-1 from wheat production.

1. Introduction

An agricultural training program is a series of formal and informal, a short-or long-term educational activity that is prepared for an individual or group of farmers to achieve defined objectives [1]. More specifically, agricultural training interventions are designed to facilitate knowledge or skill transfers on specific agricultural issues supposed to benefit farmers [2, 3]. As to [2], the training content (new technology or innovation) might not necessarily be new to farmers, but rather they may not have widely adopted it. Moreover, agricultural training is "*a potentially effective method to diffuse relevant new technologies to increase productivity and alleviate rural poverty...*" [4].

According to [5], agricultural education and training "*provides a range of educational activities with the primary aim of achieving human resource development throughout the rural economies of almost all nations*". Education, including training and extension services, is a fundamental need for human development in rural areas and also for the expansion and modernization of rural economies. The creation and expansion of training and extension networks for both men and women are very important to develop and improve skills and to increase productivity and income-generating capabilities [6].

In this regard, Ethiopia has introduced Farmer/Pastoralist Training Centers (F/PTCs) since 2002 [7] aimed at providing extension, training, demonstration, exhibition, and information services to the farm family (farmers as well as pastoralists), and the rural youth [8, 9]. Even though the government and donors have invested a substantial amount of resources in these centers, "their expected impact remains unclear due, in part, to the near absence of any rigorous impact evaluation" [10], of which one is the impact of training. Regarding the training impact evaluation [2], commented that "…there is a clear need for more and better designed primary research into the effects of training on African smallholder farmers" at large.

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Some studies related to the impact of training at FTCs are conducted in Ethiopia contributing their own to the existing literature. However, at least one of the studies' objectives focused on the impact of training either on income, saving, livelihood, technology adoption, or productivity merely depended on descriptive analysis and even some lacked empirical evidence. For instance [11], claimed that farmers who participated in the modular training program at FTCs had raised their level of living based on the opinions of the focus groups and key informants than on the data collected from the trainees and non-trainees. Similarly [12], assessment on the effect of the modular training program both on the intermediate (knowledge acquisition and skill development, technology adaptation and use) and the ultimate outcome (income improvement and saving) to farmers was based only on the responses of training participants without comparing with their counterparts though the study had both participant and non-participant groups as sample respondents. In addition [13], used a 'Yes' or 'No' question instead of using the income data of the participant and non-participant farmers to measure the income difference between the two groups to see the effect of the modular training program provided at FTCs [14]. also reported that the FTC-based training had positive impact on farm productivity, income, and saving status of the participants with no data on the mentioned outcome variables. Similarly [15], claimed that training had positively impacted the wealth, income, saving status, and technology adoption behavior of the participants. But, there were no data (before and after training) to justify his claim about the observed differences. As to the authors' knowledge, it is only [16] who studied the impact of modular training at FTCs in Eastern Ethiopia on households' income using econometric analysis employing a propensity score matching (PSM) method. However, this study didn't see whether training has an impact on crop productivity besides households' income.

Similarly, studies conducted in other parts of the world on the impact of training in agriculture also employed merely descriptive analysis. For instance [17, 18, 19], in Pakistan [20]; in Iraq [21]; in Zambia; and [22, 23, 24, 25, 26], in India, all used descriptive than econometric analysis for their study. But [27], in Zimbabwe used multiple regression using ordinary least squares (OLS) which is often blamed to yield a biased estimate [28, 29, 30, 31, 32] as it does not account for systematic differences between training participants and non-participants. The results drawn from such studies are therefore questionable.

Thus, to address the above gaps, this study applies the mixed-methods research approach and the PSM econometric model to investigate the impact of training at FTCs on crop productivity and households' income in the east Gojjam zone of Amhara region.

The paper is organized into five sections. The second section presents the research methodology undertaken by the study. The third and fourth sections present results and discussion, respectively. The fifth concludes and recommends.

2. Materials and methods

In this section, study area description, sampling design, data collection and data analysis, and descriptions of study variables are presented.

2.1. Description of the study area

The study was conducted in Gozamin and Machakil[1]Woredas in the East Gojjam zone of Amhara region (Figure 1). East Gojjam zone is one of the 11 zones in the region. It has 18 Woredas and 4 town administrations. Its capital, Debre Markos, is 300 km away to the northwest of Addis Ababa, and 265 km from the capital of the region, Bahir Dar. The zone lies at 10° 20′ North latitude and 37° 43′ East longitude. It is bordered in the North by South Gondar zone, in the South by Oromia region, in the East by South Wollo zone, and in the West by West Gojjam zone [33].

Its altitude ranges from 800-4200 m above sea level (masl). The mean annual rainfall ranges from 900-1800 mm while its mean temperature from 7.5oC-27 °C [34]. The zone is located in the Blue Nile Basin of Ethiopia where the Choke Mountains with an elevation of 4100 masl are found. The zone is divided into three major traditional agro-ecologies, namely mid-altitude (*Woyna Dega*), high altitude (*Dega*), and lowland (*Kolla*), in their order of dominance. The major soil types include Cambisols, Leptosols, Luvisols, Nitisols, Phaezems, and Vertisols [34].

Agriculture is the main source of rural livelihood in the zone characterized by a mixed rain-fed farming system. It is the agro-potential area where surplus production takes place in the region. Teff is the most dominant cereal crop produced in the zone. Other major crops following teff, by area coverage, include wheat, maize, barley, faba bean, sorghum, sesame, haricot bean, and triticale. The major livestock includes cattle, sheep, goat, poultry, donkey, horse, mule, and honey bees [34].

2.2. Sampling design

2.2.1. Sampling technique and sample size for the quantitative data

The study employed a multi-stage sampling procedure. First, the east Gojjam zone was purposively selected since about 95% of the FTCs are fully functional by status [35] compared to those established in the west Gojjam zone where only 74% of them are functional [36]. Next, two Woredas (Gozamin and Machakil) from the selected zone were purposively selected based on the performance of training provision at FTCs conducted during the 2016/2017 cropping season and other extension services, compared to other Woredas. This was done in consultation with the agricultural extension experts in the zonal bureau of agriculture.

In the study Woredas, a total of 6,081 farmers (90% of the total assessed ones) were trained and certified (given Certificate of competence (COC)) by the regional Technique and Vocational Education and Training (TVET) Agency for the level-I training given at FTCs on crop production in the 2016/17 cropping season (Table 1).

Among the total 50 Kebeles[2] (25 in each Woreda) in the study Woredas, a total of 4 Kebeles were further selected purposively based on the number of households trained and certified. This was also done through close consultation and discussion with experts of the respective Woredas. Thus, two Kebeles (Yegagina from Gozamin and Laydamot from Machakil) and the other two (Aba Libanos and Qerer-emenba from Gozamin and Machakil, respectively) were selected as control and treatment Kebeles, respectively (Table 2). The control Kebeles were made to be non-adjacent to the treatment Kebeles in the respective Woredas to minimize the spillover effect of the training, at least at the village level. Since the population of the selected Kebeles is finite and known, the total sample size of the respondents was determined by using [37]'s formula:

$$n = \frac{N}{1 + N(e^2)} = \frac{4,068}{1 + 4,068\ (0.05^2)} = 364.18 \approx 364,$$

where, n = the desired sample size; N = total number of population and, e = the level of precision which is equal to 0.05.

The above sample size determination formula was further used at e = 10% precision level for each Kebele population to check the representativeness of the sample taken based on the probability proportional to size (PPS) sampling technique. As a result, a total of 364 (180 trainees and 184 non-trainees) respondents were selected based on the second stage sample size determination technique from the selected Kebeles. However, to overcome non-response and missing data problems, a 10% contingency of the total sample size was kept, which finally made the overall sample size to be 401 (Table 2).

Trainees were used as a treatment group and the non-trainees as a control one. The selection of sample respondents from both groups followed the systematic random sampling technique. This was done based

[1] '*Woreda*' is the fourth level administrative unit in Ethiopia equivalent to district.

[2] *Kebele*' is the smallest administrative unit in Ethiopia.

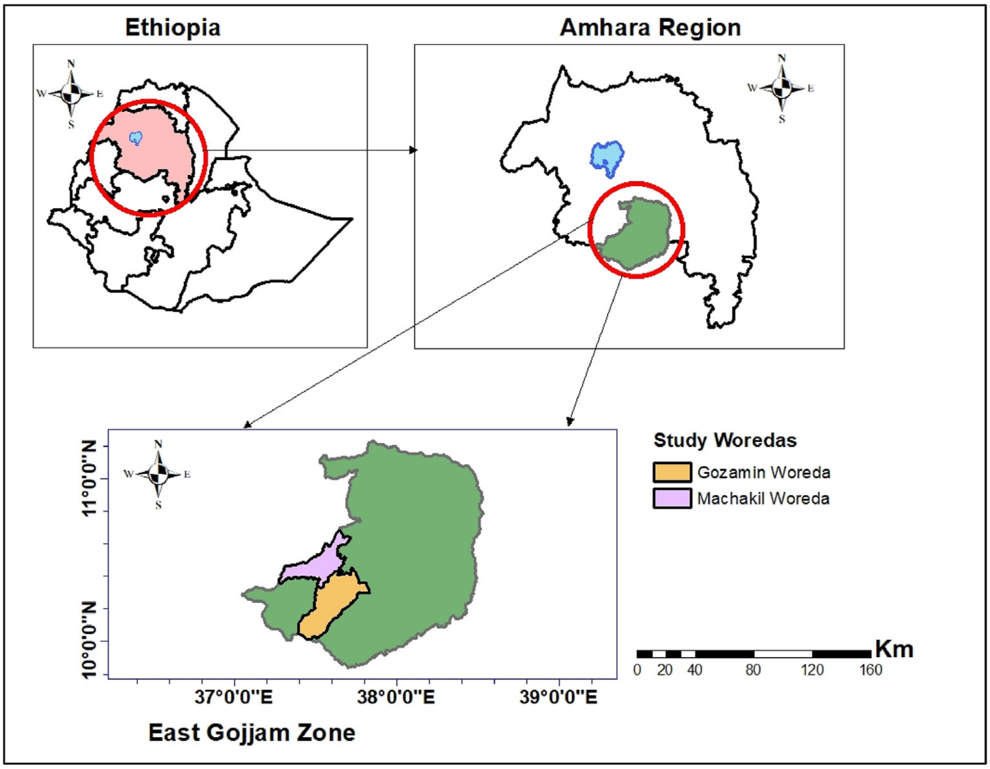

Figure 1. Location map of the study areas. Source: ArcGIS desktop (ArcMap 10.5), 2016.

Table 1. Training participation at FTCs by study Woreda

Woreda	Trained			Assessed			Certified (COC given)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Gozamin	4286	69	4355	2485	37	2522	2243	30	2273
Machakil	10,430	567	10,997	4,080	146	4,226	3,680	128	3,808
Total	14,716	636	15,352	6,565	183	6,748	5,923	158	6,081

Source [35].

Table 2. Distribution of sample size by sample Kebeles and training participation.

Sample Woredas	Sample Kebeles	Total No. of Household Heads (HHs)	Sample size (PPS) (1st stage)			Sample size with a 10% precision level at each Kebele (2nd stage)		
			Trainees	Non-trainees	Total	Trainees	Non-trainees	Total
Gozamin	Yegagina	1064	-	95	95	-	95	95 (105)
	Aba Libanos	1531	137	-	137	94	-	94 (103)
Machakil	Lay Damot	833	-	75	75	-	89	89 (98)
	Qerer-Emenba	640	57	-	57	86	-	86 (95)
Total	4	4,068	194	170	364	180	184	364
Contingency (10%)						18	18.4	36.4
Grand total						198	203	401

Source: Own computation, 2020.

on the list of farmers found at the sample Kebeles through the help of the FTC heads and development agents working there.

2.2.2. Sampling technique and sample size for the qualitative data

The focus of the qualitative data was mainly on the objectives and orientation (theoretical or practical) of the training, materials and facilities made available, and stakeholders' involvement and role during the training process. Thus, to gather these data, a total of 18 key informants were purposively selected based on the responsibilities they hold at various levels. Besides, three out of the planned four focus groups (each with seven members) were purposively contacted to collect the data (Table 3). However, one focus group discussion was canceled as a national level movement restriction was declared due to the COVID-19 pandemic during the data collection period.

Table 3. Sample size distribution by administrative levels and participants.

Levels	Key informants	Number	Focus groups	Number
Zone	Extension team leader	1	-	-
	Training expert	1	-	-
Woreda	Extension team leader	1	-	-
	Training expert	1	-	-
Kebele	FTC heads (one from each study Kebele) Development agents (DAs) involved as trainers in the 2016/17 cropping season DAs (2 from each Kebele)	4 2 8	*Community members (both trainees and non-trainees) from sample Kebeles (7 members per group; trainees = 4, non-trainees = 3)	3
	Total	18		3 (21 members)

* The group participants were none of those interviewed for the quantitative data to avoid any possible bias.

2.3. Methods of data collection

Both quantitative and qualitative data were collected for the study. The quantitative data were collected from sample households through a semi-structured interview schedule in the study Kebeles. The interview schedule is similar to the survey questionnaire. The difference is, in the former case, it is the enumerator who interviews the target respondent and records the data, whereas it is the respondent who reads and records the data in the later case. For this study, the former method was chosen since many of the respondents were unable to read and write to record the data by themselves. The themes included in the interview schedule were characteristics of the household head and household members; farm resources, production cost and income of the household; access to market, extension, credit and information; and attitudes and perceptions of the household head. The interview schedule was first pretested to include relevant variables and avoid unnecessary ones. Training was also given to a total of eight interviewers before the actual data collection process began. In addition, the qualitative data were collected from the selected key informants and focus groups (Table 3) through interviewing and focus group discussions, respectively. Checklists were prepared and used for this purpose.

2.4. Methods of data analysis

Descriptive and econometric analyses were made for the quantitative data. The propensity score matching method (PSM) was employed to analyze the impact of training on crop productivity and the net annual crop income of the households in the study areas. Thematic analysis was used for the qualitative data.

2.4.1. The propensity score matching (PSM) model

The alternative to the experimental approach is the use of quasi-experimental approaches, which seek to create, using empirical methods, a comparable control group that can serve as a reasonable counterfactual [38, 39]. These approaches try to estimate the impact of an intervention when individuals are not randomly assigned to treatment and control groups.

Some common quasi-experimental approaches to evaluate the impact of development programs include propensity score matching (PSM), difference-in-difference (DID), regression discontinuity design (RDD), and instrumental variables (IV) estimation [16, 29, 40, 41, 42]. As to [42], the selection of a proper impact evaluation method depends on understanding the assignment rules of the program.

Thus, this study employed the PSM over the DID approach due to lack of baseline data, i.e. data on the crop yield and income status of farmers before the FTC-based training program implemented in the 2016/17 cropping season, in the study areas. The RDD approach can't also be applied since there was no evidence that individuals assigned to the treatment group, i.e. farmers who were involved in the training program, were based on the observable eligibility criteria, (i.e. either by income or productivity levels). In addition to the above-mentioned reasons, PSM remains an influential approach to estimate the impact of an intervention in a fairly straightforward manner [38].

In this study, the treatment assignment is participation/non-participation in the training program at FTCs which was offered in the 2016/17 cropping season in the study areas. Whereas, crop productivity (crop yield per hectare) and annual crop income are the outcome variables. Since the selected sample Kebeles are wheat (Triticum aestivum) and maize (Zea mays) cluster areas, the data on yield and crop income were made specific to the two crops only. Thus, the income obtained on grain selling from the two crops was used to separately compute the total annual crop income. That is, the change in household income is calculated as a function of total yields obtained and the market price of the respective crops [2].

Inference about the impact of treatment on the outcome of an individual involves speculation about how this individual would have performed had s/he not received the treatment. The standard framework in evaluation analysis to formalize this problem is the potential outcome approach or Roy-Rubin-model [43, 44]. The main pillars of this model are individuals, treatment, and potential outcomes. In the case of a binary treatment, the treatment indicator Di equals one if individual i receives treatment (i.e. if participated in the training) and zero (i.e. if not participated in the training) otherwise. The potential outcomes are then defined as Yi (Di) for each individual i, where i = 1... N, and N denotes the total population. The treatment effect for an individual i can be written as (Equation 1):

$$Ti = Yi(1) - Yi(0), \tag{1}$$

where Ti is the program/treatment effect for an individual i, Yi (1) and Yi (0) are the potential outcomes with and without the program, respectively. In our case, the potential outcomes are yield and net annual household income gained from wheat and maize production.

In general, following [45], the mean impact of the training is obtained by averaging the impact across all the individuals in the population, which is known as the average treatment effect (ATE), and defined as (Equation 2):

$$ATE = E(Y1 - Y0) \tag{2}$$

Another parameter of interest is the average treatment effect on the treated (ATT) measuring the impact of the training on those households who participated (Equation 3):

$$ATT = E(Y1 - Y0 / D = 1) \tag{3}$$

PSM has two basic assumptions stated as follows [45]:

Assumption 1. (Conditional Independence Assumption or CIA): there is a set of covariates (X), observable to the researcher, such that after controlling for them, the potential outcomes are independent of the treatment status (Equation 4):

$$(Y1, Y0) \perp d | X \tag{4}$$

The CIA is crucial for correctly identifying the impact of the training since it ensures that, although trainees and non-trainees differ, these differences may be accounted for to reduce the selection bias. This allows the non-trainees to be used to construct a counterfactual for the trainees.

Assumption 2. (Common Support Condition): for each value of X, there is a positive probability of being both treated and untreated (Equation 5):

$$0 < P(D = 1|X) < 1 \tag{5}$$

This implies that the probability of receiving treatment (i.e. training) for each value of X lies between 0 and 1. This means, by the rule of probability, the probability of not receiving the training lies between the same values. This is also known as overlap condition because it ensures that there is sufficient overlap in the characteristics of the trainees and non-trainees to find adequate matches (or common support).

When these two assumptions are satisfied, the treatment assignment is said to be strongly ignorable [46].

2.5. Summary of outcome, treatment, and exogenous variables

The outcome, treatment and exogenous variables used in this syudy are summarized below (Table 4).

3. Results

In this section, the findings of the study are presented in the consecutive sub-sections with descriptive and econometric analyses of the data, respectively.

3.1. Descriptive analysis

3.1.1. Wheat and maize production

Wheat and maize are the major cereals produced in the study areas. The majority of the whole respondents (87%) and the trainees (95%) and non-trainees (79%) produced these cereals together in the 2018/2019 cropping season (Table 5). Having the potential of producing such cereals, the study areas are targeted, among others, as cluster areas for the respective commodities based on the cluster farming approach introduced in the country with the aim of commercializing the smallholder agriculture [47].

3.1.2. The impact of training on crop productivity and households' income

Hereinafter, crop productivity refers to wheat and maize yield per hectare, and crop income refers to the income obtained from the two crops in Ethiopian birr per hectare in the 2018/19 main cropping season.

The net crop income was calculated by subtracting the input costs incurred for each crop per hectare from the gross income. The gross income was calculated by multiplying the total output of each crop obtained per hectare by the respective market prices. The major inputs on which farmers incurred costs were taken to be improved seeds, fertilizer (NPSB[3] and urea), and herbicides (Table 6). The costs for these inputs were solely considered as the data were readily available and more reliable than other production costs at the household level.

For wheat, there is a significant difference in costs incurred for the production inputs between trainees and non-trainees (Table 6). Trainees incurred lower costs for improved seeds and herbicides compared to the non-trainees. But, they incurred higher costs for fertilizer (NPSB and urea). As the interview made with key informants revealed, this is because the trained farmers tended to apply the recommended rate of inputs while the non-trained farmers tended to over- and under-apply inputs. As the key informants pointed out, for instance, the non-trained farmers tend to over-apply improved seeds and herbicides, and under-apply fertilizer against the recommended amount per hectare.

Table 4. Summary of outcome, treatment, and exogenous variables.

Variable	Description
Outcome variables:	
Wheat yield	Total annual wheat yield obtained (kg ha-1)
Wheat net income	Wheat annual net income earned (birr ha-1 in '000)
Maize yield	Total annual maize yield obtained (kg ha-1)
Maize net income	Maize annual net income earned (birr ha-1 in '000)
Treatment variable:	
Training participation	Household head's participation in training (1 = yes; 0 = no)
Exogenous variables:	
Sex	Sex of the household head (1 = male; 0 = female)
Age	Age of the household head (years)
School year	Household head's education level (school year)
Farm experience	Household head's farming experience (years)
Health condition	Household head's health condition (1 = unhealthy; 2 = somewhat healthy; 3 = healthy)
Household size	Total household size (adult equivalent)
Land ownership	Household head land ownership status (1 = formally owned/inherited; 0 = no)
Radio ownership	Household head radio ownership status (1 = yes; 0 = no)
Mobile ownership	Household head mobile ownership status (1 = yes; 0 = no)
Farmer-to-farmer extension	Household head's access to farmer-to-farmer extension service (1 = yes; 0 = no)
Extension contact	Household head's extension contact (No. of contacts per month)
Cooperatives	Household head's cooperatives membership status (1 = yes; 0 = no)
Training sources	Household head's access to other training sources (1 = yes; 0 = no)
Travel frequency	Household head's frequency of travel to urban centers per month (number of travels)
Training usefulness	Household head's perceptions of usefulness of the training (1 = not useful; 2 = undecided; 3 = fair; 4 = useful)
Training room convenience	Household head's perceptions of the training room convenience (1 = inconvenient; 2 = undecided; 3 = fair; 4 = convenient)
DAs' competence	Household head's perceptions of development agents' (DAs) competence (1 = incompetent; 2 = undecided; 3 = fair; 4 = competent)
Kebele cabinet	Household head's membership status in the Kebele cabinet (1 = yes; 0 = no)
FTC distance	Distance of farmers training center (FTC) from household head's residence (km)

Table 5. Distribution of respondents by types of crops grown.

Crops grown	Full sample		Trainees		Non-trainees	
	Freq.	%	Freq.	%	Freq.	%
Teff	3	0.75	-	-	3	1.48
Wheat	12	2.99	3	1.52	9	4.43
Maize	36	8.98	6	3.03	30	14.78
Wheat & maize	350	87.28	189	95.45	161	79.31
Total	401	100	198	100	203	100

Source: Field survey result, 2020.

[3] A blended fertilizer prepared from nitrogen, phosphorous, sulfur, and boron minerals.

Table 6. Average input costs of wheat and maize production by training participation (birr ha-1).

Cost item	Wheat			Maize		
	Trainees (N = 190)	Non-trainees (N = 170)	t (p-value)	Trainees (N = 195)	Non-trainees (N = 191)	t (p-value)
Improved seed	3386.98 (58.98)	3892.91 (62.09)	5.91 (0.0000***)	589.99 (20.66)	622.19 (23.91)	1.02 (0.3083)
NPSB	3894.02 (156.50)	2891.82 (107.94)	-5.15 (0.0000***)	2925.23 (91.53)	2979.16 (81.09)	0.44 (0.6599)
Urea	1933.49 (95.33)	1490.86 (68.69)	-3.69 (0.0003***)	2642.12 (104.45)	2258.04 (80.95)	-2.89 (0.0040***)
Herbicide	232.89 (19.65)	305.02 (32.91)	1.93 (0.0548*)	-	-	-

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$; Standard errors in parenthesis.
Source: Field survey result, 2020.

Table 7. Yield and net income gained from wheat and maize production by training participation.

Outcome variable	Trainees		Non-trainees		Difference	t (p-value)
	Mean	S.D	Mean	S.D		
WY (kg ha-1)	4096.88	1154.59	3180	971.40	916.88	-8.12 (0.000***)
NWI (birr ha-1 in '000)	45.85	16.65	37.43	16.01	8.42	-4.88 (0.0000***)
MY (kg ha-1)	3286.55	982.81	3050.14	933.67	236.41	-2.38 (0.0178**)
NMI (birr ha-1 in '000)	23.33	9.11	22.15	7.70	1.18	-1.34 (0.1793)

WY = wheat yield; NWI = net wheat income; MY = maize yield; NMI = net maize income.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.
Source: Field survey result, 2020.

For maize production, only the cost incurred for urea is significantly different between the trainees and non-trainees at a 1% level of significance. This implies that trainees apply larger amounts of urea per hectare than the non-trainees for similar reasons the key informants had justified for wheat production. The insignificance of input costs incurred for seed and NPSB for maize than wheat production between the trainees and non-trainees indicates that there were no knowledge and skill gaps on seed and NPSB applications between the two groups. This is because farmers of the area are more familiar and have a long time experience of implementing the maize production technologies recommended by the Sasakawa Global-2000 extension strategy, initiated in Ethiopia in 1993 [48,49], for the past two and half decades. As the t-test shows (Table 7), the mean difference of wheat and maize yield harvested between trainees and non-trainees is significant at 1% and 5%, respectively. Besides, the annual mean net income earned from wheat production significantly differs between trainees and non-trainees at a 1% level of significance. However, the mean difference of the annual net income of maize is found to be insignificant between the two groups. The significant maize yield but insignificant net income of the same found compared to wheat is essentially due to the existing market opportunity for the respective crops. As disclosed by the key informants (training experts), farmers are more curious to attend the technical training given for the crops which they think have a better market demand, keeping the quality of the training is constant. In this regard, in the study area, wheat than maize is produced as cash crop which has a higher market demand by the nearby flour factories. This indicates that during the training program, wheat farmers compared to maize were more interested to get trained on the technicalities of how to increase yield per hectare and how to improve the qualities of the produce (to meet the standards of the flour factories) before and after the harvest to secure high yield and high income per hectare. This implies that the keen participation in training and application of the knowledge acquired and skills developed out of it is guided not only by the yield but also by the market incentives that farmers are expecting for what they are producing.

However, a simple mean comparison between the two groups may give us a misleading conclusion that the observed difference in crop yield and the respective net income is only due to the training intervention. Therefore, further analysis with propensity score matching (PSM) method is crucial to disentangle the impact of training on crop yield and income between farmers who participated in the training program and those who did not. Following are empirical results presented based on the PSM analysis.

3.2. Econometric analysis

Before conducting an econometric analysis, a multicollinearity diagnosis was made for the exogenous variables. Variance inflation factor (VIF) is one of the indicators of collinearity [50]. The variables sex and age were found to have a VIF above 10. Hence, sex was removed from the analysis and the square of age (age 2) was taken to address the collinearity issue (Appendix Table A1).

3.2.1. The propensity score matching (PSM) analysis

To assess the impact of training on crop productivity and households' income, this study used a psmatch2 STATA command to estimate the propensity score for matching purpose by employing a binary probit regression model (Appendix Table A2, A3, and A4). The nearest neighbor, kernel, radius, and caliper matching techniques were applied to balance the covariates between the trainees and non-trainees. The absolute standardized means difference (B) and the variance ratio (R) values were used as criteria to select a matching method that can ensure a sufficient balance between the two groups. The absolute standardized differences between treatment groups for each covariate are recommended than conducting t-tests to compare the covariate values for the two groups [51]. According to [52], matching techniques with $B < 25\%$ and R between 0.5 and 2 can be taken for granted that the samples are sufficiently balanced. Thus, the kernel and radius matching techniques are found fulfilling [52]'s criteria over others to estimate the training effect on the aforesaid outcome variables (Appendix Table A5). In addition, the common support assumption is graphically checked to be sure whether the trainees have enough matches with their counterparts. The common support graph is presented only for the kernel-based matching technique as it has the lowest standardized mean difference compared with the radius matching technique (Figure 2).

Table 8 portrays that training had a significant positive impact on wheat and maize yield at a 1% level of significance. Besides, it had a significant impact on the net income of wheat and maize at a 1% and 10% significance level, respectively.

However, PSM is limited to consider unobserved covariates (hidden bias) while estimating the effect of an intervention on the treated and

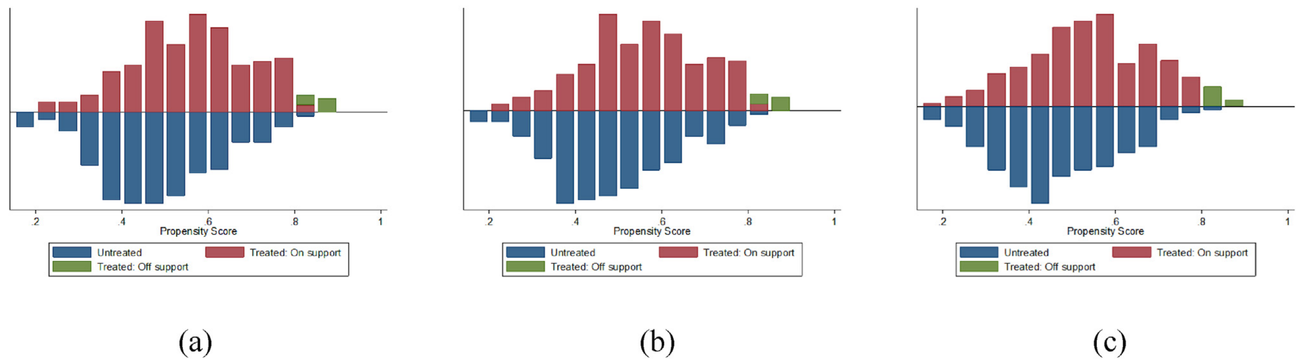

Figure 2. Propensity score distribution and common support for propensity score estimation with a kernel matching technique [(a): wheat yield outcome variable; (b): wheat net income outcome variable; (c): maize outcome variables]. Note: "Treated": "on support" denotes cases in the trainees' category having a suitable comparison from the non-trainees category, and "Treated": "off support" denotes cases in the trainees' category having no suitable comparison from the same.

Table 8. The impact of training on wheat and maize productivity and households' income (Kernel based matching algorithm, bandwidth = 0.06).

Outcome variables	Sample	Trainees	Non-trainees	Difference	S.E	T-stat	Average treatment effect with bootstrap standard error			
							ATT	Bootstrap S.E	Z	P>|z|
WY (kg ha-1)	Unmatched	4096.88	3180	916.88	112.95	8.12	-	-	-	-
	ATT	4086.49	3226.33	860.16	120.45	7.14***	860.16	138.83	6.20	0.000***
NWI (birr ha-1 year-1in '000)	Unmatched	45.85	37.43	8.42	1.726	4.88	-	-	-	-
	ATT	45.63	38.14	7.49	1.867	4.01***	7.49	2.045	3.66	0.000***
MY (kg ha-1)	Unmatched	3286.54	3050.14	236.41	99.28	2.38	-	-	-	-
	ATT	3285.95	2984.39	301.56	108.32	2.78***	301.56	109.03	2.77	0.006***
NMI (birr ha-1 year-1 in '000)	Unmatched	23.33	22.15	1.18	.874	1.35	-	-	-	-
	ATT	23.31	21.75	1.56	.946	1.65*	1.56	.893	1.75	0.080*

WY = wheat yield; NWI = net wheat income; MY = maize yield; NMI = net maize income.
***p < 0.01; **p < 0.05; *p < 0.1.
Source: Field survey result, 2020.

control groups [29, 53]. This implies that PSM estimates are not robust against hidden bias due to unobserved variables that simultaneously affect assignment to treatment and the outcome variables [54]. Thus, sensitivity analysis proposed by [55] is carried out to check whether the results obtained by covariate matching are sensitive to unobserved factors (Table 9).

Table 9 above indicates that robustness to hidden bias differs across the outcome variables. Our finding of the positive effect of training on maize net income is sensitive to a hidden bias (unobserved factors) with the lowest critical value (Γ) of 1.01 for the 90% confidence interval and of 1.31 for the Hodges-Lehmann point estimate. This means that we cannot confidently conclude tha the positive effect found is due to the training intervention as the hidden bias magnitude (Γ) is lower implying that the result is sensitive to unobserved factors which are not captured by PSM. These unobserved factors might include farmer's motivation, his/her prior knowledge and skills, and the ability of managing maize production, etc, However, for wheat yield, the lowest critical value (Γ) that includes zero is 3.4 (95% confidence interval) and 5.4 (Hodges-Lehmann point estimate). This means that the confidence interval and the Hodges-Lehmann point estimate for wheat yield effect would include zero if an unobserved variable caused the odds ratio of the treatment assignment (training participation) to differ between trainees and non-trainees by a factor of 3.4 and 5.4, respectively. This is strong evidence that the result found is insensitive to hidden bias. That means the positive wheat yield effect is associated with the training intervention. For wheat net income, the lowest gamma (Γ) value that includes zero is 1.9 (95% confidence interval) and 2.7 (Hodges-Lehmann point estimate). Likewise, the evidence is strong that the result found is insensitive to hidden biases.

For maize yield, the lowest gamma value is 1.2 (95% confidence interval) and 1.7 (Hodges-Lehmann point estimate) which is fairly larger. Generally, the hidden bias magnitude (Γ) required to challenge the conclusions about the positive effects of training on the three outcome variables, except maize net income, is relatively larger and thus the impact estimates found are insensitive to hidden biases.

4. Discussion

This study, as mentioned before, was aimed at assessing the impact of training on crop productivity and households' income. The discussion is made based on the PSM analysis results with the kernel matching technique (still having the lowest per cent of bias (B) compared to the radius matching technique) (Appendix Table A5).

As the PSM analysis results signify (Table 8), training was found to have a positive impact on the yield and net income of wheat, and maize yield at a 1% level of significance. But, the positive impact on maize net income at a 10% level of significance was found to be sensitive to possible hidden biases (Table 9). These possible hidden biases might include, but not limited to farmer's motivation, his/her prior knowledge and skills, and the ability of managing maize production. Thus, it is difficult to conclude that the observed impact is only due to training. Households who were trained and get certified by the regional TVET agency increased their wheat yield by 860.16 kg ha-1 (26.66%) and maize yield by 301.56 (10.10%) kg ha-1. The wheat growers also earned an additional net annual income of 7,490 (19.64%) Ethiopian birr ha-1.

This finding agrees with the findings of training impact studies conducted in different parts of the world. To mention [56, 57, 58, 59, 60, 61, 62, 63, 64], found that training has a positive significant impact on crop

Table 9. Rosenbaum bounds sensitivity analysis by outcome variables (Kernel matching algorithm, bandwidth = 0.06).

Outcome variable	*Gamma (hidden bias magnitude)	Significance level		Hodges-Lehmann point estimate		Confidence interval (95%)	
		upper bound	lower bound	upper bound	lower bound	upper bound	lower bound
Wheat yield (kg ha-1)	1	2.8e-15	2.8e-15	902.698	902.698	707.293	1093.13
	2	.000011	0	514.837	1279.24	312.152	1481.46
	3	.007773	0	305.433	1487.9	67.3658	1714.46
	3.1	.011389	0	287.815	1504.37	46.5598	1735.6
	3.2	.016179	0	270.354	1521.32	26.3379	1755.55
	3.3	.022348	0	253.181	1537.23	5.5909	1774.61
	3.4	.030089	0	237.798	1553.08	-10.8594	1792.03
	4	.117203	0	152.366	1634.09	-109.049	1887.92
	5	.400121	0	32.4502	1749.65	-227.191	2010.93
	5.1	.432392	0	19.4553	1762.28	-237.443	2021.96
	5.2	.464475	0	9.72024	1770.81	-249.618	2032.68
	5.3	.496172	0	1.68402	1779.74	-256.868	2043.54
	5.4	.5273	0	-9.33009	1788.98	-264.469	2051.62
Wheat net income (in ‘000 birr ha-1 year-1)	1	6.4e-08	6.4e-08	7.67643	7.67643	4.86032	10.374
	1.1	1.1e-06	2.5e-09	6.89615	8.40895	4.05947	11.0665
	1.2	.000012	9.2e-11	6.15835	9.14767	3.33205	11.8322
	1.3	.000077	3.2e-12	5.47176	9.81392	2.72201	12.5079
	1.4	.000371	1.1e-13	4.86988	10.3689	2.1226	13.0749
	1.5	.001368	3.4e-15	4.32216	10.8397	1.57158	13.59
	1.6	.004073	1.1e-16	3.78405	11.3686	1.04115	14.0718
	1.7	.010181	0	3.30321	11.8597	.539349	14.5796
	1.8	.022011	0	2.91341	12.3542	.07997	15.0423
	1.9	.042154	0	2.47432	12.7514	-.411635	15.4756
	2	.072906	0	2.09184	13.1039	-.83785	15.9194
	2.5	.389293	0	.387565	14.715	-2.65621	17.8096
	2.6	.469825	0	.095027	15.0206	-2.99061	18.1208
	2.7	.548534	0	-.186282	15.3175	-3.33203	18.4064
Maize yield (kg ha-1)	1	.001326	.001326	235.075	235.075	82.1905	392.101
	1.05	.003239	.0005	214.555	256.627	61.804	417.21
	1.1	.007059	.000183	194.881	279.125	40.1629	438.779
	1.15	.013934	.000065	175.728	300.416	19.2788	460.093
	1.2	.025238	.000023	156.315	317.049	-.360678	481.874
	1.25	.042406	7.6e-06	137.816	336.222	-19.7912	501.948
	1.3	.066711	2.5e-06	119.767	355.656	-36.9964	525.14
	1.4	.139739	2.7e-07	83.6981	390.539	-68.0076	567.959
	1.5	.244305	2.6e-08	55.1584	423.765	-97.0015	606.025
	1.6	.370918	2.5e-09	25.6437	452.7	-121.886	636.881
	1.7	.504524	2.3e-10	-.955894	482.527	-146.854	668.765
Maize net income (in ‘000 birr ha-1 year-1)	1	.064087	.064087	.999053	.999053	-.290937	2.35105
	1.01	.071669	.05714	.958715	1.04427	-.329796	2.3953
	1.1	.166425	.018866	.603291	1.37935	-.643468	2.76405
	1.2	.320774	.004802	.289682	1.72051	-1.01328	3.14615
	1.3	.4985	.001088	.003831	2.01882	-1.3039	3.48846
	1.31	.516128	.000933	-.028229	2.04707	-1.32239	3.52099

* - gamma (Γ) - log odds of differential assignment due to unobserved factors.
Note: The lowest critical values of gamma for Hodges-Lehmann point estimate and 95% CI including zero are bolded.
Source: Stata output, 2020.

productivity. And [65, 66, 67, 68] found that training has positively impacted households' annual income. In addition [69, 70, 71], in their study showed that training significantly affects both crop yield and enhancement of the annual net income of participant households.

The results of PSM analysis found thus indicate that training enhanced the technical production skills of the participants than the non-participants. This production skills improvement helped the households to increase the wheat and maize yield, and thereby their net annual income per hectare. According to the interviewed key informants, the training offered in the 2016/17 cropping season was themed nationally in Amharic as "Yesebil lemat niqnaqe", which means "a campaign of crop development". The program was given due emphasis by the Ministry of Agriculture and the regional bureaus of the same. As the interviews revealed, the training was aimed at imparting skills mainly on the use of modern inputs with the recommended rates (fertilizer and lime application, improved seeds) and improved agronomic practices (line sowing and spacing, weed management).

The interview made with key informants and the focus group discussion made with the training participants disclosed that the training was more practical with the fulfillment of necessary training materials.

They also witnessed that there was close supervision of experts and higher officials at the National, Regional, Zonal, and Woreda levels. It is believed that the practicality of the training given and the special attention and follow-up of the program by experts and higher officials at various levels motivated the trainees to seriously attend the training program and develop the necessary technical skills required for modern wheat and maize production, which further lead them to increase the yield and annual net income. However, the key informants and the focus group participants also commented that:

> The training given for the next batches of trainees in the consecutive periods (2017/18, 2018/19, and 2019/20) declined in terms of practicality, supply of training materials, close supervision and follow-up, unlike the one given in 2016/17. As a result, the training program less attracted the participants and there was a high record of absentees than attendants, thereby leading to a likely decline in the benefits of the training on the farm households' crop productivity and the respective income.

5. Conclusion and recommendations

This paper assesses the impact of training at FTCs on crop productivity and households' net annual income in the east Gojjam zone of Amhara region. The study employed the PSM econometric model. About 87% of the respondents produced wheat and maize together in the study areas. The sensitivity analysis that was made to check whether the PSM results obtained by covariate matching are sensitive to unobserved factors reveals that the positive effect of training on wheat yield, wheat net income, and maize yield are insensitive to hidden biases implying that these positive effects are associated with the training intervention. However, the positive impact of training on maize net income is found to be sensitive to unobserved factors implying it is difficult to conclude that the observed impact is only due to training. In a nutshell, the PSM results show that the training offered in the 2016/17 main cropping season followed by the certification of competent farmers had a significant positive impact on crop yield (wheat and maize) and annual income (wheat) of farm households in the study area. The significant maize yield but insignificant respective net income found compared to Wheat is essentially due to the existing market opportunity for these produces which catalyzes farmers' interests to objectively attend the technical training. This implies that the keen participation in training and application of the knowledge acquired and skills developed out of it is guided not only by the yield but also by the market incentives that farmers are expecting for what they are producing.

Therefore, FTCs should focus on and sustain offering practical training on new technologies and best practices on specific crops contingent on their economic importance to help farmers develop modern production knowledge and skills and thereby increase their yield and annual net income per hectare. Besides, the government at various levels should capacitate the FTCs in terms of fulfilling the required training materials to ensure that the training being offered is more practical than theoretical. Furthermore, there has to be regular close supervision and evaluation to make sure whether the training being given is of standard, timely, and as desired to make the training "make a difference". Finally, further research is needed in the region and elsewhere in the country to substantiate the findings of this study. If so, it would help to revisit or formulate the training policies at the FTC level either regionally or nationally to best exploit the benefits of training programs that will be implemented in the future.

Declarations

Author contribution statement

Ketemaw Melkamu Wonde: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Abrham Seyoum Tsehay: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Samson Eshetu Lemma: Conceived and designed the experiments.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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Appendix A

Table A1. Multicollinearity diagnostics.

Variable	Before correction		After correction	
	VIF	1/VIF	VIF	1/VIF
Sex	23.79	0.042041	-	-
Age (age 2)	10.61	0.094279	3.93	0.254555
School year	4.00	0.250275	3.74	0.267555
Farm experience	4.61	0.216760	4.30	0.232482
Health condition:				
Somewhat healthy	2.00	0.500267	1.94	0.515708

(*continued on next column*)

Table A1 (*continued*)

Variable	Before correction		After correction	
	VIF	1/VIF	VIF	1/VIF
Healthy	1.99	0.501940	1.95	0.513100
Household size	3.98	0.251461	3.80	0.263193
Land ownership	2.07	0.483027	2.01	0.496340
Radio	2.31	0.433365	2.26	0.443086
Mobile	2.10	0.476380	2.05	0.487479
Farmer-to-farmer extension	2.15	0.466143	2.03	0.491726
Extension contact	3.16	0.316546	2.93	0.341569
Kebele cabinet	2.08	0.481064	2.06	0.485555
Cooperatives	2.14	0.466749	2.12	0.471782
Other training sources	2.27	0.440703	2.24	0.447020
Travel frequency	3.67	0.272661	3.42	0.292449
Training room convenience:				
Fair	1.55	0.643816	1.52	0.656823
Convenient	1.46	0.684022	1.42	0.705952
Training usefulness:				
Fair	1.77	0.564498	1.72	0.582598
Useful	1.70	0.589758	1.68	0.596968
DAs' competence:				
Fair	1.52	0.658910	1.48	0.677236
Competent	1.44	0.692547	1.42	0.706284
FTC distance	4.09	0.244491	3.99	0.250625
Mean VIF	3.76		2.45	

Source: Stata output.

Table A2. Probit regression for wheat outcome (yield) variable to estimate propensity score.

training	Coef.	Std.Err.	z	P > z	[95%Conf.	Interval]
agesq	-9.48e-06	.0000361	-0.260	0.793	-.0000802	.0000612
schoolyr	.0314656	.0223267	1.410	0.159	-.012294	.0752252
farm_exp	-.0053285	.0041682	-1.280	0.201	-.0134981	.0028411
healthco						
Somewhat_healthy	-.1311346	.1732168	-0.760	0.449	-.4706333	.2083641
Healthy	.130297	.1696065	0.770	0.442	-.2021257	.4627196
hh_size	.011528	.0260925	0.440	0.659	-.0396124	.0626684
lnd_ownership	.2338818	.1379668	1.700	0.090	-.0365281	.5042918
radio	-.1553825	.1418429	-1.100	0.273	-.4333895	.1226244
mobile	-.267852	.1385634	-1.930	0.053	-.5394313	.0037272
FtoF_ext	.1962907	.1391256	1.410	0.158	-.0763906	.4689719
extn_cont	.0178034	.0337607	0.530	0.598	-.0483664	.0839732
kebele_cabnt	.235158	.1388162	1.690	0.090	-.0369168	.5072329
coop	-.1652997	.1399091	-1.180	0.237	-.4395164	.108917
trn_source	.1035906	.1381558	0.750	0.453	-.1671899	.374371
trvl_frqcy	.0151467	.0291153	0.520	0.603	-.0419182	.0722116
trrom_conv						
Fair	.0705966	.1673632	0.420	0.673	-.2574293	.3986225
Convenient	-.1348181	.1753286	-0.770	0.442	-.4784558	.2088196
tr_useful						
Fair	.1901379	.1644171	1.160	0.248	-.1321136	.5123894
Useful	.3272778	.1735637	1.890	0.059	-.0129007	.6674563
DA_comptnc						
Fair	.3757864	.1728614	2.170	0.030	.0369843	.7145885
Competent	-.1372693	.1736964	-0.790	0.429	-.4777079	.2031694
ftc_dist	-.0105855	.0123435	-0.860	0.391	-.0347783	.0136072
_cons	-.2522911	.4005129	-0.630	0.529	-1.037282	.5326998
Log likelihood	-234.48748	LR chi 2 (22)	31.53	Number of obs. = 362		
Pseudo R2	0.0630	Prob > chi 2	0.0858			

Source: Stata output.

Table A3. Probit regression for wheat outcome (net income) variable to estimate propensity score.

training	Coef.	Std.Err.	z	P > z	[95%Conf.	Interval]
agesq	-.000011	.0000361	-0.300	0.760	-.0000818	-.9955305
schoolyr	.0283002	.0224333	1.260	0.207	-.0156683	.0722687
farm_exp	-.0057364	.0041882	-1.370	0.171	-.0139451	.0024723
healthco						
Somewhat healthy	-.1593402	.1744397	-0.910	0.361	-.5012357	.1825552
Healthy	.1283246	.1696775	0.760	0.449	-.2042372	.4608863
hh_size	.0097923	.0261248	0.370	0.708	-.0414114	.0609961
lnd_ownership	.2319995	.1382286	1.680	0.093	-.0389237	.5029227
radio	-.1376455	.1423833	-0.970	0.334	-.4167116	.1414206
mobile	-.2688347	.1387797	-1.940	0.053	-.5408379	.0031686
FtoF_ext	.1933626	.1393971	1.390	0.165	-.0798507	.466576
extn_cont	.0140399	.033879	0.410	0.679	-.0523616	.0804415
kebele_cabnt	.2198965	.1392419	1.580	0.114	-.0530127	.4928056
coop	-.1620122	.1403151	-1.150	0.248	-.4370249	.1130004
trn_source	.1220911	.1387989	0.880	0.379	-.1499497	.3941318
trvl_frqcy	.016191	.0292335	0.550	0.580	-.0411055	.0734876
trrom_conv						
Fair	.0618685	.1679726	0.370	0.713	-.2673518	.3910888
Convenient	-.1282172	.1754949	-0.730	0.465	-.4721809	.2157466
tr_useful						
Fair	.1896678	.1651161	1.150	0.251	-.1339538	.5132894
Useful	.3433883	.1741015	1.970	0.049	.0021556	.684621
DA_comptnc						
Fair	.3819559	.1730239	2.210	0.027	.0428353	.7210765
Competent	-.1516701	.1748116	-0.870	0.386	-.4942946	.1909544
ftc_dist	-.0109328	.0124391	-0.880	0.379	-.0353129	.0134473
_cons	-.2078868	.4018664	-0.520	0.605	-.9955305	.579757
Log likelihood	-233.08756	LR chi 2 (22)	31.78	Number of obs. = 360		
Pseudo R2	0.0638	Prob > chi 2	0.0812			

Source: Stata output.

Table A4. Probit regression for maize outcome (yield and net income) variable to estimate propensity score.

training	Coef.	Std.Err.	z	P > z	[95% Conf.	Interval]
agesq	.0000124	.0000357	0.350	0.728	-.0000575	.0000824
schoolyr	.0268112	.0217741	1.230	0.218	-.0158652	.0694876
farm_exp	-.008262	.0042398	-1.950	0.051	-.0165718	.0000478
healthco						
Somewhat_healthy	-.1117942	.1712725	-0.650	0.514	-.447482	.2238937
Healthy	.2232962	.1662024	1.340	0.179	-.1024545	.5490468
hh_size	.0002525	.02538	0.010	0.992	-.0494913	.0499963
lnd_ownership	.1966414	.1364812	1.440	0.150	-.0708568	.4641395
radio	-.1455571	.1400668	-1.040	0.299	-.420083	.1289688
mobile	-.3150209	.1367052	-2.300	0.021	-.5829581	-.0470837
FtoF_ext	.2121426	.137473	1.540	0.123	-.0572995	.4815847
extn_cont	-.0158555	.033002	-0.480	0.631	-.0805383	.0488273
kebele_cabnt	.2622702	.1372489	1.910	0.056	-.0067328	.5312732
coop	-.2086155	.1380914	-1.510	0.131	-.4792697	.0620386
trn_source	.0287112	.1366985	0.210	0.834	-.2392129	.2966354
trvl_frqcy	-.0082542	.0285436	-0.290	0.772	-.0641985	.0476902
trrom_conv						
Fair	.1506881	.1647104	0.910	0.360	-.1721384	.4735147
Convenient	-.0326126	.1739115	-0.190	0.851	-.3734729	.3082478
tr_useful						
Fair	.1233185	.1623826	0.760	0.448	-.1949456	.4415827
Useful	.2326937	.1694313	1.370	0.170	-.0993855	.5647729

(*continued on next column*)

Table A4 (*continued*)

training	Coef.	Std.Err.	z	P > z	[95% Conf.	Interval]
DA_comptnc						
Fair	.3313628	.1684514	1.970	0.049	.0012041	.6615214
Competent	-.0636683	.1761903	-0.360	0.718	-.408995	.2816584
ftc_dist	-.0046173	.0123834	-0.370	0.709	-.0288883	.0196538
_cons	-.0379759	.3912353	-0.100	0.923	-.804783	.7288312
Log likelihood	-241.65151	LR chi 2 (22)	33.76	Number of obs = 373		
Pseudo R2	0.0653	Prob > chi 2	0.0519			

Source: Stata output.

Table A5. Matching techniques by matching quality criteria.

Impact indicators	Matching method	Trainees	Non-trainees	B (absolute standardized mean difference)		R (variance ratio)	
				Unmatched	Matched	Unmatched	Matched
Wheat yield (kg ha-1)	Nearest neighbor (n = 1)	185	170	60.3*	55.9*	1.16	1.37
	Kernel (bw = 0.06)	185	170	60.3*	14.7	1.16	1.08
	Radius (0.02)	185	170	60.3*	20.5	1.16	0.81
	Caliper (0.02)	185	170	60.3*	44.2*	1.16	1.15
Net wheat income (birr ha-1)	Nearest neighbor (n = 1)	183	170	60.7*	44.6*	1.15	1.53
	Kernel (bw = 0.06)	183	170	60.7*	14.8	1.15	1.07
	Radius (0.02)	183	170	60.7*	19.2	1.15	1.05
	Caliper (0.02)	183	170	60.7*	44.6*	1.15	1.53
Maize yield (kg ha-1)	Nearest neighbor (n = 1)	180	185	61.4*	41.6*	1.17	1.60
	Kernel (bw = 0.06)	180	185	61.4*	12.2	1.17	1.19
	Radius (0.02)	180	185	61.4*	20.3	1.17	0.96
	Caliper (0.02)	180	185	61.4*	41.6*	1.17	1.60
Net maize income (birr ha-1)	Nearest neighbor (n = 1)	180	185	61.4*	41.6*	1.17	1.60
	Kernel (bw = 0.06)	180	185	61.4*	12.2	1.17	1.19
	Radius (0.02)	180	185	61.4*	20.3	1.17	0.96
	Caliper (0.02)	180	185	61.4*	41.6*	1.17	1.60

* If B>25%, R outside [0.5; 2].
Source: Stata output.

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