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Impacts of Adoption of Improved Coffee Varieties on Farmers' Coffee Yield and Income in Jimma Zone

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Abstract

This study was conducted in four districts of Jimma zone namely Gera, Manna, Limu Kosa and Gomma to estimate the relative benefits of use of improved coffee varieties on adopters' livelihood (income) and yield. Multistage sampling technique was employed to select the population for the study which involved both purposive and random sampling techniques. Data was collected through structured questionnaire administered to sampled farmers. Both descriptive and inferential statistics, and econometric models were used to analyze the gathered and cleaned data. The impact of adoption of the improved coffee varieties on yield and income was estimated using propensity score matching (PSM) technique. The result of the survey revealed that the mean adoption rate of improved coffee cultivars was 53.56%. The mean overall clean coffee yield per hectare was 769kg/ha which is higher than the national average estimated by CSA (710kg/ha) by 8.3%. On other hands, the mean clean coffee yield per hectare of land for adopters is significantly higher (861 kg) than their non-adopters counter parts (646kg). To extract the net increment due to use of improved coffee varieties, PSM was run. Accordingly, from the total increment the use of improved coffee varieties increased clean coffee yield per hectare by 25.3-28.8% over the non-adopters. Concomitantly, the use of improved coffee varieties increased coffee income by 33.6-46.6 % and total income by 25.8-44.1% over non-adopters using different matching algorithms. Government and non-government organizations need to emphasize on diffusion of improved coffee technologies to their maximum capacity. This would increase their productivity per unit of land which in turn raise farmers' income and livelihood.

Keywords: Adopter; Inferential; Non-adopter; Productivity and PSM

Abbrevations: CIP: Coffee Improvement Project; CWD: Coffee Wild Disease; CBD: Coffee Berry Disease; PSM: Propensity Score Matching; ATE: Average Treatment Effect; ATT: Average Treatment Effect on the Treated; CIA: Conditional Independence Assumption; CSC: Common Support Condition

Introduction

The sustainable contribution of agriculture to economic growth and development, poverty reduction and food security enhancement could only be achieved through an increase in productivity of smallholder farmers using improved technologies [1]. Agricultural innovations play a significant role in fighting poverty, lowering per unit costs of production [2], boosting rural incomes and reducing hunger [1]. Many studies have been conducted to assess the adoption of different agricultural technology and their impact on productivity, welfare and poverty reduction in rural areas [3-8]. The results of these empirical studies revealed the positive impact of adoption of improved crop varieties on households' income, productivity and livelihoods.

Coffee accounts over 35% of agricultural foreign exchange earnings and 4% of agricultural gross domestic product. It also provides income to over 15 million people in the country directly or indirectly through provision of jobs for farmers, local traders, processors, transporters, exporters and bankers [9].

Jimma agricultural research center has devoted considerable effort and resource and developed several coffee technology packages. To increase the contribution coffee to economic growth through enhancing coffee production and productivity, coffee improvement project (CIP) has been developed. The government negotiated with European Union (EU) for a grant to finance the project. The agreement was signed between EU and Ethiopian government in 1977 and the implementation was carried out in different faces to introduce better coffee management practices with intensive extension, to construct rural roads and cooperative stores, to conduct intensive coffee research and to provide coffee related farm inputs on credit basis. The contribution of CIP for coffee producing areas of Ethiopia was substantial and significant in coffee development history of Ethiopia. Due to the establishment of CIP, several hectares of land were planted or replanted with CBD resistant selections, many kilometers of access road were constructed, thousands of hectares of old coffee trees rejuvenated, and generally coffee production and productivity had increased significantly [10,11].

Since then, the center has released 34 pure line and 6 hybrids totally 40 coffee varieties for different coffee belts of the country. The varieties disseminated and diffused to both smallholder and commercial farmers through different forms and approaches of coffee extension interventions. The improved coffee varieties released by Jimma agricultural research center offer new opportunities for farmers because of their unique characteristics of high cup (sensory) quality, higher yield and huge tolerance to major coffee disease such as CWD (coffee wild disease) and CBD (coffee berry disease) than the traditional cultivars/varieties. In addition to these technologies, several recommendations have been developed on pest and disease management, agronomic and soil fertility management. Despite the diffusion and dissemination of these improved coffee technologies, the relative benefits of use of improved coffee technologies has not been studied in Ethiopia. This study was designed to evaluate the economic contribution of the use of improved coffee varieties on the livelihood of adopters of the technology. More specifically, the study was set:

a. To measure the rates and intensities of adoption of improved coffee technologies on the study area.

b. To truck the impacts of coffee production technologies (improved coffee varieties) on farmers' coffee yields and income.

The result of the study could be helpful for coffee related biological and physiological researchers, academicians, private investors and policy makers.

Methodology

Study area description

The study was conducted in four districts of Jimma zone namely Gera, Manna, Limu Kosa and Gomma districts. Gera district is found in the southwest of Jimma Zone. It shares border with Chekorsa to the south east, with Gomma to the east, with Setema to the north east, with Sigmo to the north west, with Shebe Sombo to the south and the south Ethiopian people's nations and nationalities to the west and south west. Its absolute location ranges between 7027' to 7055' north latitude and 38001' to 36024' east longitude. Tropical, Semi-tropical and temperate agro climates respectively shares 15%, 35% and 50% of the district's total area. The mean annual temperature of the district ranges from 15-22 ˚C. The vast area of the district's annual rainfall varies between 1300mm and 1700mm. Coffee and teff are the major local cash crops in the district. Limu Kosa district extends between 7050' to 8036' north latitudes and 36044' to 37029' east longitudes. It is bordered with Limmu Seka district in north and West Shewa Zone in north east, with Tiro Afeta in southeast, with Manna and Kersa districts in south, with Buno Bedele zone and Gomma district in west. It is situated in the north central part of the zone.

Sub-tropical and temperate agro climates do respectively constitute 70% and 15% of the district's areas. The remaining 15% of the district's agro climate does have tropical climate. The mean annual temperature of the district ranges from 18-23 ˚C. The mean annual rainfall of the district ranges from 1300-2300mm. Maize and coffee are the main crops grown in the district. Gomma district extends between 7040' to 8004' north latitudes and 36017' to 360 46' east longitudes. It is bordered with Didesa district in north, with Limmu Kosa district in east, with Manna district in southeast, with Seka Chekorsa in south and with Gera district in west. It is situated in the central part of the zone. Most part of the district belongs to subtropical and temperate agro climates. Sub-tropical and temperate agro climates do respectively constitute 88% and 12% of the district's area. The mean annual temperature of the district ranges between 15 ˚C and 22 ˚C. The vast area of the district's annual rainfall varies between 1700mm and 2100mm. Maize and coffee are also the main crops grown in the district. Manna district extends between 7038' to 7054' north latitudes and 36038' to 36053' east longitudes. It is bordered with Gomma and Limmu Kosa districts in north, with Kersa district in east, with Seka Chekorsa district in south and with Gomma district in west. It is also situated in the central part of the zone. Sub-tropical and temperate agro climates do respectively constitute 80% and 20% of the district's total areas. The vast part of the district does have with mean annual temperature ranges between 18 ˚C and 20 ˚C. The district has mean annual rainfall which lies between 1300 and 1700mm. Maize and coffee are the main crops grown in the district JANRD (Figure 1).

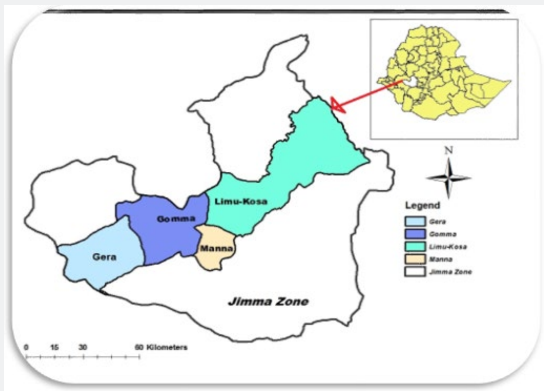

Figure 1: Map of the study districts.

Sampling procedure

Multistage sampling technique was employed to select the population for the study which involved purposive and random sampling techniques. First, districts were purposively picked, and secondly kebeles were selected using lottery method. Finally, households were randomly chosen from the sampling frame (list of farmers) exist at kebele level. A total of 205 households were selected for the study.

Data collection and analysis

Data was collected through structured questionnaire administered to sampled farmers. Before the actual survey, the questionnaire was pretested in non-sampled villages. The pretest was

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not only used to test the appropriateness of the tool in collecting the required data but also to evaluate the trained enumerators on the capability of administering the questionnaire. Information related to coffee production and utilization was gathered from the respondents. Households' socio demographic, institution and economic features were also collected. Data were cleaned, organized and analyzed using STATA version 14.2 software. Both descriptive and inferential statistics were used to analyze the gathered and cleaned data. The impacts of adoption of the improved varieties of coffee on households' coffee yield and income was analyzed using propensity score matching (PSM) technique.

Rates and intensity of adoption

Adoption of improved technologies in this study is defined as the use of both improved coffee varieties that have been popularized and disseminated among farmers since the establishment of CIP (1977 G.C). Adoption can be measured in terms of the number of persons who adopt the technology (adoption rate) or in terms of the total area on which the technology is adopted (adoption intensity). Intensity of adoption of improved coffee variety is the ratio of land covered by improved coffee to total coffee land of the farmer.

Impact of adoption of improved coffee varieties

The propensity score matching (PSM) was used to empirically determine the impact of adoption improved coffee varieties on farmers' yield and income. It refers to the pairing of treatment and control units with similar values on the propensity score, and possibly other covariates, and the discarding of all unmatched units. It is an alternative method to estimate the effect of receiving treatment when random assignment of treatments to subjects is not feasible. This method made comparison between those who had adopted and those who had not adopted and drawn conclusions based only on those who have adopted improved coffee varieties. Since it is impossible to know the outcomes for non-adopters of improved coffee varieties when they have adopted, and for adopters when they have not adopted, we turn to propensity score matching (PSM) to determine the average treatment effect on the treated farmers (ATT). In such a case, the average treatment effect (ATE) can be computed as:

$$ATE = E\left(Y_1 \mid D=1\right) - E\left(Y_0 \mid D=1\right)$$

This assumes that the output levels of the adopters before their adoption $E(Y_0|D=1)$ can reasonably be approximated by the output level of non-adopters during data collection $E(Y_0|D=0)$. Otherwise, estimation of ATE using the above equation is not possible since we do not observe $E(Y_0|D=1)$ though we do observe $E(Y_1|D=1)$ and $(E(Y_0|D=0)$. However, technologies are rarely randomly assigned. Instead, technology adoption usually occurs through self-selection of farmers or, sometimes, through program placement. In the presence of self-selection or program placement, the above procedure may result in a biased estimation of the impacts of improved technologies since the treated group (i.e. the adopters) are less likely to be statistically equivalent to the comparison group (i.e. the non-adopters) in a non-randomized setting.

PSM adjusts for selection bias, minimizes the limitation from matching on many observed variables and estimates counter-factual effects. PSM according to Rosenbaum & Rubin [12] is given as:

$$P\left(X\right) = \Pr\left\{D=1 \mid X\right\} = E\left\{D \mid X\right\}$$

Where, D = {0, 1} is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics.

The PSM method is a systematic procedure of estimating counter-factual for the unobserved values (E(Y1|D=0) and $E(Y_0|D=1)$ to estimate impact estimates with no (or negligible) bias. The validity of the outputs of the PSM method depends on the satisfaction of two basic assumptions namely: The Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) [13]. CIA (also known as Unconfoundedness Assumption) states that the potential outcomes are independent of the treatment status, given X. Or, in other words, after controlling for X, the treatment assignment is "as good as random". The CIA is crucial for correctly identifying the impact of the program, since it ensures that, although treated and untreated groups differ, these differences may be accounted for in order to reduce the selection bias. This allows the untreated units to be used to construct a counter factual for the treatment group. The common support condition entails the existence of enough overlap in the characteristics of the treated and untreated units to find adequate matches (or a common support). When these two assumptions are satisfied, the treatment assignment is said to be strongly ignorable.

Estimation of the propensity score is not enough to estimate the ATT of interest. Because propensity score is a continuous variable, the probability of observing two units with the same propensity score is, in principle, zero. Four commonly used matching algorithms, namely nearest neighbor matching, radius matching, stratification and kernel-based matching were employed to assess the impact of improved coffee technologies on households' yield.

Radius matching: In this method, every treated subject is matched with a corresponding control subject that is within a predefined interval of the treatment subject's propensity score. Since each of the treatment subjects must be matched with a control subject with a given interval, only a certain number of comparisons will be available [14].

Nearest neighbor matching method: It matches each farmer from the adopter group with the farmer from the non-adopter group having the closest propensity score. The matching can be done with or without replacement of observations. Nearest neighbor matching method faces the risk of bad matches if the closest neighbor is far away. This risk can be reduced by using a radius matching method which imposes a maximum tolerance on the difference in propensity scores. However, some treated units may not be matched if the dimension of the neighborhood is too small to contain control units [15].

The kernel-based matching method: It uses a weighted average of all farmers in the adopter group to construct a counter-factual. The major advantage of the kernel based matching

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method is that it produces ATT estimates with lower variance since it utilizes greater information; its limitation is that some of the observations used may be poor matches.

Stratified matching: The propensity scores are classified into intervals based on the range of values. Each interval consists of treatment and control subjects that on average, have equivalent propensity scores. The differences between the outcomes of the treatment and the control group are calculated to obtain the average treatment effect. It is an average of the outcomes of a treatment per block weighted by the distribution of treated subjects across the blocks [14].

Asymptotically, all matching algorithms should yield the same results. However, in practice, there are trade-offs in terms of bias and efficiency involved with each algorithm [15]. It is known that coffee is perennial crop which gives the production after three years. This is the initial stage of coffee development. In this study of impact analysis, especially on the yield, we must deduct the land covered by newly established coffee of less than three years. Therefore, the comparison between the yield of the treated and the non-treated group will be carried out based on the following equation:

$$ACCY = \frac{TCCY}{TCL - NCL}$$

Where: ACCY: is the average clean coffee yield in kg per hectares of land.

TCCY: is the total clean coffee yield produced in kg.

TCL: is total coffee land in hectares.

NCL: is new coffee land planted in the last three years in hectares.

Result and Discussion

Socio economic characteristics of respondents

The study was conducted on four coffee potential districts of Jimma zone in Oromia regional state. Total number of respondents interviewed was 205. Out of the total respondents, 95.1% were male headed households and the rest 4.9% were female headed.

Table 1: Sex and education level of adopters and non-adopters.

Variables		Adopters in % (n=118)	Non-Adopters in % (n=87)	P value
Household Head Sex	Male	57.9	42.1	0.62
	Female	50	50	
Household Head Education	Illiterate	32.4	67.6	0.004***
	Read and Write	71.4	28.6	
	Primary (1-8)	58.9	41.1	
	Secondary (9-12)	72.7	27.3	
***, Significance Level at 1%				

Source: Survey result, 2018.

Table 2: Age and family size of adopters and non-adopters

Income Sources	Adopters (N=118)		Non-Adopters (N=87)		P-value
	Mean	S.E	Mean	S.E	
Mean Household Head Age	43.67	0.96	47	1.3	0.041**
Family Size	6.7	0.19	6.5	0.25	0.502
**, Significance Level at 5%					

Source: Survey result, 2018.

Table 3: Land holding of adopters and non-adopters.

Variables	Adopters		Non-Adopters		P-value
	Mean	S.E	Mean	S.E	
Mean Total Land [ha]	2.51	0.178	1.63	0.177	0.001***
Mean Coffee Land [ha]	1.81	0.16	1.05	0.12	0.000***
Mean Number of Plots	2.64	0.12	1.89	0.1	0.000***
***Indicate significance level at 1%					

Source: Survey result, 2018.

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Out of total male respondents, more than halve have adopted improved coffee varieties. On other hands, half of female headed households have adopted the technology. There was no statistically significant difference between male and female headed households in adoption of coffee technologies. The education status of respondents showed most of non-educated households did not adopted improved coffee varieties and most of the respondents who read and write only has adopted. As indicated on Table 1, there was a significant difference between adopters and non-adopters in education status at 1% significance level.

Table 2 below showed that the mean age of adopters was lower than their non-adopters' counterparts which is statistically significant at 5% significance level. On other hands, adopters have more family size than non-adopters though no statistically significant difference. When we see the land holding, adopters have significantly large total and coffee land size than non-adopters. On other hands, adopters have large number of coffee plots than non-adopters which is also significant at 1% significance level (Table 3).

Table 4 below shows the income of adopters and non-adopters. The result revealed that non-adopters have significantly more non-farm income than adopters which is significant at 1% significant level. However, adopters have significantly more total and coffee income.

Table 4: Income of adopters and non-adopters in ETB.

Description	Adopter		Non-adopters		P-vale
	Mean	S.D	Mean	S.D	
Income from other Crops	5,759.95	6412.4	4,665.40	6417.06	0.229
Non-Farm Income	6,713.62	10662.14	3,351.12	6722.18	0.006***
Coffee Income	41,145.52	31085.23	29,535.81	36868.75	0.018**
Total Income	53,619.11	37178.71	37,552.35	40712.9	0.004***
Note: 1$ = 27.34 ETB on February 2018					
***, **Indicate Significance Level at 1% and 5% Respectively.					

Source: Survey result, 2018.

Table 5: Livestock holding of adopters and non-adopters.

Variables	Adopters		Non-Adopters		P-value
	Mean	S.E	Mean	S.E	
Cows [Exotic and Local]	1.93	0.24	1.28	0.14	0.020**
Oxen	1.38	0.12	0.82	0.09	0.000***
Bulls	0.74	0.1	0.51	0.09	0.09*
Heifer	0.83	0.13	0.62	0.11	0.211
Calves	0.95	0.12	0.68	0.11	0.108
Goat	1.46	0.22	0.77	0.15	0.01**
Donkey	0.27	0.05	0.24	0.04	0.673
TLU	6.19	0.623	4.06	0.415	0.009***
***, **, *; Significance Level at 1%, 5% and 10% Respectively.					

Source: Survey result, 2018.

Livestock holding on the study area showed that adopters had significantly a greater number of cows, oxen, bulls and goat as compared to their non-adopter counterparts. The mean number of TLU (tropical livestock unit) was 6.19 and 4.06 for adopters and non-adopters, respectively which is significant at 1% significance level (Table 5).

Adoption of improved coffee varieties

The rate of adoption of improved coffee cultivars was important criteria to evaluate the extension system used for diffusion and farmers' acceptance for the varieties. The result of the survey revealed that the mean adoption rate for the improved coffee cultivars was 55%. However, the rate of adoption was significantly different among the study locations at 1% significance level. Highest rate of adoption was seen at Gera district and the lowest was at Manna (Figure 2). Coffee is perennial crop and its extension system needs special care, patience and devotion. The difference among the districts could be related to the emphasis given to coffee extension by the districts and the extension intensity of coffee improvement project (CIP).

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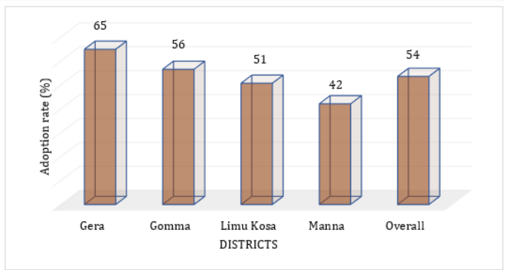

Figure 2: Adoption rate by districts in %.

Adoption rate by gender showed that the percentage of the male farmers who adopted the improved coffee cultivars is higher than that of the female counterparts. Even though no significant difference in adoption rate, 58% and 50% of male and female headed households adopted the improved coffee cultivars respectively. The main reason for this could be low exposure of female headed households for training, meetings, farmers' field days and other extension systems.

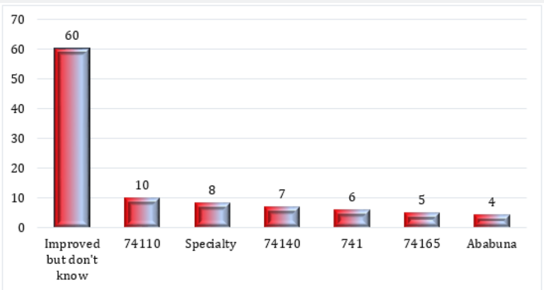

Figure 3: Coffee improved varieties used among adopters in %.

Adopters were also asked which improved coffee varieties they grown on their land. They mentioned about nine improved coffee varieties they have grown. However, more that 60% of respondents do not know the name of the improved varieties they planted. The most commonly known and mentioned variety by the farmers were 74110 which is a pure line variety selected during CIP. Concomitantly, specialty, 74140, 741 and 74165 are pure line (selection) coffee varieties were adopted among the adopters. Ababuna was hybrid coffee varieties adopted among only 4% of adopters (Figure 3).

Intensity of adoption of improved coffee varieties

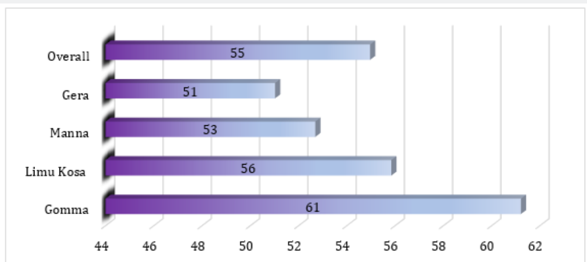

Figure 4: Intensity (%) of adoption by location.

Intensity of adoption of improved coffee technologies was measured among the adopters by the percentage of coffee land covered by the improved cultivars. The mean adoption intensity was 55%. The intensity of adoption among districts revealed that Gomma district adopters covered the highest proportion of their land by the improved cultivars. The lowest proportion of improved coffee was seen at Gera district where the highest rate of adoption was seen. This could be caused due to large mean land holding of the districts as compared to other districts (Figure 4).

Adoption intensity also differs between male and female headed households. The result showed that mean adoption intensity of male headed households (56%) is higher than that of female headed households (55%). However, there was no significant difference statistically in terms of the intensity. When we see the productivity (yield per hectare) among adopters and non-adopters, the mean clean coffee yield of adopters is significantly higher (861kg/hectares) than the non-adopters counter parts (646kg/hectares). The result is significant at 1% significance level (Figure 5).

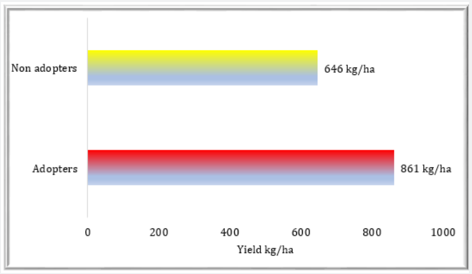

Figure 5: Productivity among adopters and non-adopters.

Propensity score matching result

Table 6: Result of probit model.

Variables	Coefficient	S.E	P>|z|
Household Head Sex	-0.076	0.499	0.88
Household Head Age	-0.021	0.009	0.020**
Family Size	0.008	0.047	0.872
Training on Coffee Technologies	0.187	0.235	0.424
Visit Coffee Demonstrations	0.552	0.206	0.007***
Dry Coffee Price	-0.063	0.036	0.077*
Number of Coffee Plots	0.365	0.096	0.000***
Radio Ownership	0.047	0.208	0.821
TV Ownership	0.649	0.252	0.010**
Constant	1.172	1.019	0.251
n = 205 ***, ** and * Indicate Significance Level at 1%, 5% and 10%, Respectively.			

Source: Survey result.

As explained on methodology, propensity score matching was implemented to see the impact of use of improved coffee variet-

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ies on the yield and income (both coffee and total income). It is a quasi-experimental option used to estimate the difference in outcomes between coffee variety adopters and non-adopters. The results of the probit model is reported in Table 6. It indicates that age of the household head, participation on coffee technology field days (demonstrations), coffee price, ownership of TV and number of coffee plots are important variables that determine farmers' propensity of adoption of improved coffee varieties.

The result of the matching showed that the common support assumption is satisfied in the region [0.21071912, 0.9957248] with a mean of 0. 611887, enforcing the exclusion of 15 non-adopters from the analysis. The Average Treatment effect on the Treated (ATT) was computed based on the four alternative matching methods for all outcome variables [log of coffee yield per hectare, log of coffee income and log of total income]. The t-statistics was based on bootstrapped standard errors with 50 replications which were used to verify whether the observed effect was significant or not.

Impact of adoption of improved coffee varieties on yield

Table 7: Estimation of ATT for coffee yield.

Type of Matching	Treated	Control	ATT	Yield Gain Over Non-Adopters kg/ha	S.E	t value
Nearest Neighbor Matching Method	118	40	0.284	183	0.051	5.552***
Radius Matching Method	118	72	0.267	172	0.045	5.960***
Kernel Matching Method	118	72	0.253	163	0.048	5.291***
Stratification Method	118	72	0.26	168	0.044	5.955***
Output variable = log of clean coffee yield kg/ha; S.E = Bootstrapped standard errors with 50 replications; ***; significance level at 1%						

Source: Survey result, 2018.

Using all four matching algorithms, ATT result is positive and significant at 1% significance level. The ATT result on nearest neighbor matching method showed that adoption of improved coffee varieties impacted positively and significantly on farmers per hectare yield. The ATT of 0.284 suggests that adoption of improved coffee variety alone increased coffee yield by 28.4% (183kg/ha clean coffee) over non-adopters. The ATT result on radius matching method is also significant with ATT=0.267. The result also implies that adoption of improved coffee variety increased the yield by 26.7% or 172kg/ha over non-adopters. The outputs of both kernel matching and stratification method is also significant with ATT of 0.253 (25.3%) and 0.260 (26%), respectively. The implication is of these results is that farmers that grow improved coffee varieties attain significantly higher yield than non-adopters. Therefore, extension of coffee varieties and technology should be given due emphasis in order to increase yields and improve coffee farmers' livelihoods (Table 7).

Impact of adoption of improved coffee varieties on coffee income

ATT result of coffee income showed positive and significant on all algorithms used. The ATT under these matching algorithms ranges from 0.336 to 0.466 implies 33.6-46.6% coffee income increment for adopters over non adopters. Using the mean coffee income of non-adopters, the result pointed out that adopters gain ETB 9,924.03-13,763.69 over non-adopter counterparts due to adoption of improved coffee varieties (Table 8).

Table 8: Estimation of ATT for coffee income.

Type of Matching	Treated	Control	ATT	Coffee Income Gain Over Non-Adopters (ETB)	S.E	t value
Nearest Neighbor Matching Method	118	40	0.343	10,130.78	0.137	2.507***
Radius Matching Method	118	72	0.466	13,763.69	0.11	4.216***
Kernel Matching Method	118	72	0.336	9,924.03	0.134	2.506***
Stratification Method	118	72	0.365	10,780.57	0.125	2.908***
Output variable = log of coffee income; S.E = Bootstrapped standard errors with 50 replications; *** Indicate significance level at 1%.						

Source: Survey result, 2018.

Impact of adoption of improved coffee varieties on total income

The result of PSM based on four major algorisms also revealed that adoption of improved coffee varieties has significant impact on total income of the households. ATT result ranges from 0.258 to 0.441 meaning use of improved coffee varieties increase the total income of the farmer by 25.8%-44.1%. Therefore, huge effort is needed from research and extension service in availing and diffusing new and improved coffee varieties and technologies in order to generate additional income for coffee producers (Table 9).

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Table 9: Estimation of ATT for total income.

Type of Matching	Treated	Control	ATT	Total Income Gain Over Non-Adopters (ETB)	S.E	t value
Nearest Neighbor Matching Method	118	40	0.285	10,702.42	0.118	2.415**
Radius Matching Method	118	72	0.441	16,560.59	0.105	4.196***
Kernel Matching Method	118	72	0.258	9,688.51	0.116	2.235**
Stratification Method	118	72	0.278	10,439.55	0.123	2.260**
Output variable = log of total income, S.E = Bootstrapped standard errors with 50 replications; **, ***; significance level at 5% and 1%						

Source: Survey result.

Testing the balance of propensity score and covariates

The main purpose of propensity score estimation is not to obtain a precise prediction of selection into treatment, but rather to balance the distributions of relevant variables in both groups. The balancing powers of the estimations are established by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched groups, equality of means using t-test and chi-square test for joint significance of the variables.

The standardized bias difference between treatment and control samples are used as a convenient way to quantify the bias between treatment and control samples. In all the cases, it is obvious that sample differences in the raw data (unmatched data) significantly exceed those in the samples of matched cases. The low Pseudo-R^2 and the insignificant likelihood ratio tests support the hypothesis that both groups have the same distribution in covariates X after matching. In addition, the indicators of matching quality show substantial reduction in absolute bias for all the outcome variables. As indicated in Table 10, the mean bias in the covariates X after matching lies below the 20% level of bias reduction suggested by Rosenbaum and Rubin [12]. These results clearly show that the matching procedure can balance the characteristics in the treated and the matched comparison groups. Therefore, the results as used to evaluate the effect of adoption of improved coffee varieties among groups of farmers having similar observed characteristics are reasonable. Comparison was therefore made between observed outcomes for adopters with those of a comparison group of non-adopters sharing a common support. The balancing information for propensity scores before and after matching is presented in table 10 below.

Table 10: PSM quality indicators before and after matching.

Indicators	Before Matching	After Matching
Pseudo-R^2	0.173	0.028
LR chi^2	46.59	9.03
P>chi^2	0	0.434
Mean Absolute Bias	29.5	12
Mead Absolute Bias	26.8	13.9
*** Indicate significance at less than 1% probability level.		

Source: Survey result.

Conclusions and Implication

The result of PSM on yield showed that use of improved coffee varieties has increased clean coffee yield per hectare by 25.3-28.4%. The ATT result of coffee income also resulted significant on all algorithms used. The ATT under these matching algorithms ranges from 0.336 to 0.466 implies 33.6% to 46.6% coffee income increment for adopters over non adopters. ATT result of total income ranges from 0.258 to 0.441 which implies that use of improved coffee varieties increases the total income of the farmer by 25.8%-44.1%. This implies that use of improved coffee varieties has significantly increased yield (productivity), coffee income and total income. This could help smallholder coffee producers to attain optimum income and maximum margin for its livelihood. Hence, government nurseries need to emphasize on seedling distribution to their maximum capacity. On other hands, there is no formally recognized enterprise which multiply and supply coffee seed. Its only research center that have limited seed multiplication sites which is incapable to satisfy huge and raising demand for improved coffee seed. Therefore, extension, research centers, Universities and NGOs should look the way coffee seed sources would be established for each coffee producing zones and districts. So that, coffee farmers would increase their productivity using the technologies which in turn raise farmers' income.

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