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Impact of Improved Coffee Variety Adoption on Coffee Productivity of Smallholder Farmers in North Western Ethiopia

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Abstract
Coffee in Ethiopia is used as main exported commodity and source of foreign currency. Despite its importance, Ethiopia coffee production system characterized as traditional, poor disseminating and little is known about its impact on coffee productivity. Therefore, this paper aim to investigate the determinant of improved coffee varieties as well its impact on coffee productivity of smallholder farmers in north western Ethiopia. Total 114 sample households (34 Improved and 80 local coffee producers) were taken through random and systematic sampling method. Descriptive and propensity score matching methods were employed to analyze the data. The result of descriptive statistics revealed that Adopters of improved coffee varieties were allocated large land for coffee, taken training on coffee variety, construct different soil and water conservation methods, access to financial service and more educated than non-adopters. The result of logit regression showed that household sex and land allocated for coffee production was the main factors determined the improved coffee varieties adoption. The PSM result revealed that improved coffee variety adoption showed statistically significance and positive effect on improving coffee productivity of adopters over the non-adopters and brought 64.20% of increment on their coffee production. This research suggests that improved coffee variety adoption is a means of coffee productivity increment and securing economic welfare of smallholder farmers. Therefore, governmental authorities and NGO should be focused on the expanding and disseminating of these improved coffee varieties over the coffee pro agro-ecologies of the country.
Keywords: Coffee, Adoption, Impact, Improved coffee variety, Annual income, Logit, PSM
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Introduction

Arabica coffee is originated from Ethiopia and Ethiopia played big role on breeding, promotion and disseminating of Arabica coffee plant to the world. As coffee grower country, Ethiopia produced only Arabica coffee and played vital role on multiplication and promotion of it over the rest of world's beneficiaries and it is superior over Robusta coffee due to its fine aroma, stronger body and pleasant acidity (Zewdu, 2016). At National level there were five million smallholder coffee producers that cover seven hundred twenty five thousand hectare of land and they were produced 4.4 Million Quintal of coffee with 6.19 Qt/ha productivity during the 2017/2018 cropping season (CSA, 2018). Coffee is the main export commodity crop and source of foreign currency to Ethiopian economy which covers 25% the total export. Besides about a quarter of the Ethiopian population livelihood depends on the production and marketing of coffee value chain (Misganaw, 2015) and (Samuel, 2016).

In Ethiopia, Coffee was produced almost in all part of its regions. Benshagul Gumuz is one of 9 regional states of the countries which produce coffee during the same cropping season. The productivity of coffee was 3.89 Qt/ha which was lower than the national coffee productivity (CSA, 2018). Wombera district is one of the Benshangul Gumuz distrcts which produced forest coffee. Forest coffee is collected natural forest where chemical inputs like herbicide, pesticide, fungicide and fertilizers are not used as agricultural inputs. Its quality is well known as Wombera coffee by the Metekel zone and North West part of the country. It traded under wollega coffee in Gimbi Market center of Ethiopia Commodity Exchange (EXC). However, due to its High demand around Metekel zone and North Western part of the country, it also traded on black market around these areas. As result, coffee production in the district was increased from year to year. Since 2010 the district has been produced 6215 quintal of coffee from 1126 ha but now it reached 16,965 quintal amount of coffee from3393 ha of land (WDAO, 2018). In the district, majority of the small holders' livelihood is dependent on coffee cultivation and it contributed a lion share in their economy. Hence, the agriculture office has been given primary priority on the enhancement of coffee production and productivity through establishment of coffee nursery site, preparation of improved coffee variety seedlings and dissemination of these seedlings to the end users. In addition to this, a smallholder farmer also brings different improved coffee varieties from neighbor Zone like Wollega and Asosa Zone(WDAO, 2018). Despite these tremendous efforts, the impact of improved coffee varieties adoption on coffee productivity of smallholder farmers is not well known in the district. Therefore, this paper is intended to investigate the impact of these improved coffee varieties adoption on coffee productivity at smallholder farmers level and share its importance to coffee pro agro ecology and coffee producer societies.

Methodology

2.1 Description the study Areas

The study conducted in Wombera district, Metekel Zone, Benshangul Gumuz National Regional state, North West of Ethiopia as indicated in fig 1 with an area coverage of 736,425 hectare of land and population 97,152(48,479 male) inhabitants (WAO, 2018). The district located 654 km far away from Addis Ababa to North West direction with geographically location of $10^0$35'12.53'' latitude 35°47'33.27" longitude(WDAO, 2018).

The district altitude ranges from 600 to 2731 masl and bounded in the West by Guba and Dangur districts, East by Kemashi Zone, by North by Bullen district and South by Asosa and Kemashi Zone. Its farming system is characterized by mixed farming and coffee planting agro-forestry practices. The district is among the coffee growing district of Benshangul Gumuz districts. It has ten coffee growing Kebele with area coverage of 3393 hectare of land out of twenty Keble's(WDAO, 2018).

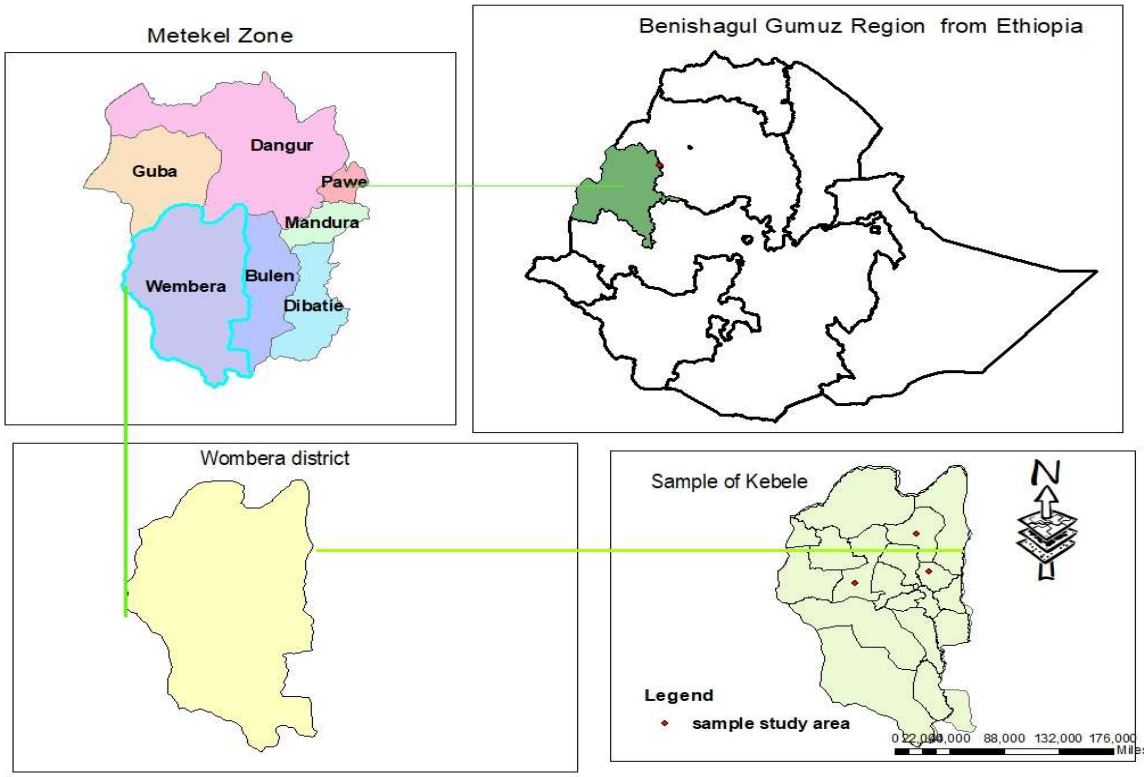

Figure 1 Map of Study Area

2.2 Method of sampling Design and Sample Size

Wombera district has ten coffee grower Keble's out of twenty administrative Keble's. These Keble's were characterized as high, medium and low coffee grower in the study area. Base on the potential of coffee growers in terms of area and coffee production these Keble's clustered in to three categories which are high, medium and low coffee producers. One Keble from each cluster was selected using simple random sampling technique. Based on this Bolelie, Mensibu and Sanki Keble were selected from the potential, medium and low coffee growing kebeles respectively. Sample unit were selected using systematic random sampling technique (SRS) with probability proportion to sample size. Accordingly 114 Smallholder coffee producers were selected from three targeted keble for this study.

In designing survey, the determination of appropriate sample size is paramount importance for inference of the findings based on the sample population. To determine the size of sample, this study adopted the following formula developed by (Yemane, 1967) as he assumed p = 0.05 that most variability of the population would be covered

$$n = \frac{N}{1+N(e)^2} \text{ ---------- 1}$$

Where: n = statistically acceptable sample size

N = Total size of target population

e = level of precision (error level) at 95%, confidence level (0.05).

Accordingly 114 sample households were taken from three Keble coffee producers.

Table 1 Smallholder Coffee producers by Keble

District	Keble	Total coffee producers	# of sample unit selected	Share of sample in %
Wombera	Bolelie	450	40	35.10
	Mensibu	380	37	32.45
	Sanki	340	37	32.45

Source: Survey data (2018)

2.3 Econometric model analysis

2.3.1 Propensity score matching (PSM)

According to (Khandker, 2010) impact evaluation is the act of studying whether the changes in well-being are indeed due to the intervention or not. The main aim of impact of improved coffee variety adoption was to determine factors affecting improved coffee variety adoption as well as to measure its impact on enhancing annual income of smallholder farmer'. To this effect, there is a need to see whether the intervention of improved coffee variety adoption has significant impact on the enhancing annual income of improved coffee variety producers' or not. However, to compare them with and without intervention, baseline survey was not conducted prior to the intervention of the improved coffee variety in the study area. Therefore, this study uses propensity score matching (PSM) method because PSM is the appropriate method when such kind of problem arises. Following (Caliendo and Kopeinig, 2008), there are some steps in implementing PSM. These are: PSM estimation, choosing matching algorithm, checking for overlap (common support), matching quality (effect) estimation and sensitivity analysis.

2.3.2 Propensity score estimation procedure

Propensity score estimation is the first step in PSM technique. When estimating the propensity score, first model and second variables choices were made. In principle any discrete choice model can be used. Preference for logit or probit models derives from the well-known shortcomings of the linear probability model, especially the unlike of the functional form when the response variable is highly skewed and predictions that are outside the [0, 1] bounds of probabilities. Estimation of participation probability gives the same result (Caliendo and Kopeinig, 2008). Hence, this study used logit model.

The matching strategy builds on the CIA, requiring that the outcome variable(s) must be independent of treatment conditional on the propensity score. Hence, implementing matching requires choosing a set of variables X that credibly satisfy this condition.

According to (Gujarati, 2009) in estimating the logit model, the dependent variable is taking a value of 1 if they Adopt improved coffee variety and otherwise 0.

The mathematical formulation of logit model is as follows:

$$Pi = \frac{e^{Zi}}{1 + e^{Zi}} - - - - - - - - - - 2$$

Where: - Pi = i^{th} household probability of adopting improved coffee variety, adopting improved coffee variety takes 1 whereas local coffee producers take 0

$$Zi = \alpha + \beta Xi + Ui \quad - - - - - - - - - 3$$

Where I= 1, 2, 3 … N, α = Intercept

β = regression coefficient to be estimated, Xi = Explanatory variables and Ui = Random error

The effect of household's adopting improved coffee variety on coffee productivity (Y) is specified as $Ti = Yi(D = 1) - Yi(D = 0) - - - - - - - - - - 4$

Where Ti = a treatment effect (effect due to adopting improved coffee variety),

Yi = is the Coffee Prouctivity on the i^{th} household

Di = is whether the i^{Th} household was adopted the coffee variety or not

However Y (Di = 1) and Yi (Di = 0) cannot be observed for the same HHs simultaneously, estimating individual treatment effects Ti is impossible and one has to shift to estimating the average treatment effects of the population than the individual one. The most commonly used average treatment effect estimation is the average treatment effect on the treated (T_{ATT}) which was E (T/D = 1) = E[Y (1) / D = 1] – E[Y (0) / D = 1] specified as follow:

$$TATT = E\left(\frac{T}{D} = 1\right) = E\left[Y\frac{(1)}{D} = 1\right] - E\left[Y\frac{(0)}{D} = 1\right] - - - - - - 5$$

Since the counter factual mean for those being treated, E (Y (0) / D = 1) is not observed, there is a need to choose a proper substitute for it to estimated ATT. Thus, it can be calculated by rearranging and subtracting E(y (0) / D = 0) from both side of equation 5 TATT.

Mathematically it expressed as follow

$$E = \left[Y\frac{(1)}{D} = 1\right] - E = \left[Y\frac{(0)}{D} = 0\right] = TATT + E\left[Y\frac{(0)}{D} = 1\right] - E\left[Y\frac{(0)}{D} = 0\right] - - - - - 6$$

In the above both terms in the left hand side are observable and ATT can be identified if no self-selection bias. That is if and only if E (y (0) however, this condition can be ensured only in a randomize experiments (i.e. where

there is no self-selection bias. Therefore, some identified assumptions must be introduced for non-experimental studies to solve the selection problems.

Basically there are two strong assumptions to selection problems those are

- Conditional independence assumption and Common support condition

The CIA is given as $Y0Y1 \quad D/X \quad X$ ---------- 7

Where CIA (indicates the outcome variable is independent of the explanatory variables which generated only due to the adoption of improved coffee variety

Xi = a set of observable characteristics Yo = old coffee producers and Y1 = Improved coffee variety producers

2.4 Co variant definition and its measurement used in the Model

Table 2 Summary of Co variant used in the model

Co variant	Measurement	Expected Sign
HH sex	Dummy, Yes/No	+
HH Age	Continuous, years of old	+
HH Edu	continuous, completed class in year	+
Model farmer	Dummy, Yes/No	+
Social contact	Dummy, Yes/No	+
Own phone	Dummy, Yes/No	+
Land in ha	Dummy, Food secure/Food insecure	+
Access to finance	Dummy, Yes/No	+
Training	Dummy, Yes/No	+
Host demo	Dummy, Yes/No	+
Coffee area	Continuous, cultivated land in ha	+
Other area	Continuous, cultivated land in ha	-
No. Extension contact	Continuous, day per year	+
Slope[1]	Discrete, state its slope	-
Depth[2]	Discrete, state its depth	+
SWC[3]	Discrete, state SWC	+

Source: Survey data (2018)

3. Result and Discussion

3.1 Descriptive statistics

Adoption of improved coffee varieties in wombera district

Wombera coffee has high demand in north western Ethiopia due to its special taste and utility. Even if wombera coffee is traded under wollega coffee in Gimbi Market center of EXC, it also traded in black market due to high demand and shortage of supply relative to its demand in Debrezeit town, the capital city of wombera district. In response of these demands the district smallholder coffee producers were adopted different improved coffee varieties to increase their coffee production and productivity during the last ten years. The improved coffee variety adoption is high in Bolelie and low in Sanki kebele both in self-perception response and area under improved coffee variety. According the response of sample households, the district improved coffee variety adoption rate is 29.82% and 40.67% in terms of self-perception response and area under improved coffee variety respectively (Table 3).

Sample households were planted different improved and local coffee varieties during the last ten years in the district. 741(1.75%) and Koti (85257)(6.14%) were among the improved coffee varieties and Kubru(37.72%), Mito(19.30%) and Bedesa(13.16%)among the local coffee were preferred and planted by sample households. However, 21.93% of the improved coffee variety producers were not knows clearly the varieties that they were planted (Table 4). The result similar with(Moti, 2013) stated that 9.7% of the respondent did not know any improved maize varieties

[1] 1 = gentle, 2 = medium, 3 = steeply
[2] 1 = shallow, 2 = medium, 3 = depth
[3] 0 = none, 1 = terrace, 2 = mulching, 3 = grass strip, 4 = trees on boundary, 5 = minimum tillage, 6 = soil bund, 7= stone bund

Table 3 Response of sample households' self-perceptions as adopters of improved coffee variety

Kebele	Adopter	Non-adopter	Allocated land in ha for coffee			% adopters response	% area covered by improved coffee
			Adopter	Non-adopter	Total		
Bolelie	17	23	47	42.25	89.25	14.91	25.24
Menesibu	10	27	21.25	29.5	50.75	8.77	11.40
Sanki	7	30	7.5	38.75	46.25	6.14	4.03
Total	34	80	75.75	110.5	186.25	29.82	40.67

Source: Survey data (2018)

Table 4 Types of improved varieties adopted by sample household in wombera district

Improved coffee varieties	Frequency	Percent
741	2	1.75
Koti(85257)	7	6.14
Improved but I did not know	25	21.93
Kubru(local)	43	37.72
Mito(local)	22	19.30
Bedesa(local)	15	13.16
Total	114	100

Source: Survey data (2018)

The district agricultural office has been established coffee nursery sites and prepared and disseminated different coffee varieties to the end users. As a result district agricultural office is the main actor on preparation, searching and disseminating of coffee seedlings. 61.4% sample households were gained their seedling from other sources like family, NGO, farmer to farmer exchange, local seedling producers while 38.6% of them were used their own saved seed (Table 5). Unlike (Misganaw, 2015), district agriculture office role on supplying of improved coffee varieties is lower(13.2%) in this paper.

Table 5 Source of coffee variety seeding

Source of coffee seedling	Frequency	Percent
Own saved seed	44	38.6
District Agriculture Office	15	13.2
Gift from family/neighbor	23	20.2
Farmer to farmer seed exchange	8	7.0
Local seedling producers	13	11.4
Provided free by NGO	11	9.6
Total	114	100.0

Source: Survey data (2018)

3.1.2 Demographic and socio economic characteristics of sampled households'

Bolelie, Menesibu and Sanki Keble were Keble of wembera district that produce coffee highly, medium and lower way respectively and chosen with to examine the impact of coffee variety adoption on coffee productivity of smallholder farmers. Improved coffee variety adopters are higher in Bolelie(14.91%) than Menesibu(8.77%) and Sanki Keble (6.14%). Adoptions of improved coffee variety among Keble were showed statically significance at 10% and positive effect on the decision to adopt improved coffee variety. Major coffee producing Keble were showed more adopter of improved coffee varieties than the medium and lower ones. Majority of the sample households sex are male headed family (92.11%) and the rests are female headed households this similar with (Moti, 2013). Sex of household head was showed that statically significance at 5% and positive effect on the decision of adopting improved coffee variety. Being male headed families are more than female headed families. Male headed families have more labor force and social network than female headed families(Kedir *et al.*, 2017). Social contact and training on new coffee varieties are also showed statically significance at 5% and 10% respectively and positive effect on the decision to adopt improved coffee variety. The variables like age, owned mobile phone and host demonstration are not showed statistical significance on the decision of improved coffee variety in this study (Table 7). This result is similar with(Welay Tesfay; Desalegn, 2019)

Table 7 Demographic and socioeconomic characteristics of sample households

Demographic and Scio-economic factors	Adopter	Non-Adopter	Total	Chi²
Kebele				**5.31***
Bolelie	17	23	40	
Menesibu	10	27	37	
Sanki	7	30	37	
Sex				**6.34*****
Male	28	77	105	
Female	6	3	9	
Age	44	42.41	42.89	0.84
Social contact				**3.62****
Yes	8	8	16	
No	26	72	98	
Mobile phone				0.26
Yes	27	60	87	
No	7	20	27	
Training on new coffee variety				**2.84***
Yes	19	31	50	
No	15	49	64	
Host Demonstration				0.02
Yes	1	2	3	
No	33	78	111	

Source: Survey data (2018)

3.1.3 Natural resources conservation habit and coffee plot characteristics

Coffee is a perennial crops which needs multiple agronomic practices, soil and water conservation practice and management throughout the year in order to gain good yield as well to protect their coffee tree from dry. As result sample households were constructed and planted different soil and water conservation to protect their coffee tree from wind, heavy rain fall, drought and animal tramping. Majority of the sample households adopted different soil and water conservation practices (61.40%) and the rest of them (38.60%) are not adopted any soil and water conservation due to their coffee land is gentle slope. Most of the coffee land slope (58.77%) and depth or its fertility (77.19%) is medium and above respectively. Only 41.23% of the sample households' coffee land is steeply (Table 8).

Table 8 Natural resources conservation habit and coffee plot characteristics

SWC practice and coffee plot characteristics	Adopter	Non-Adopter	Total	Chi²
Soil and water conservation practices on coffee plot				11.78
No practice	9	35	44	
Terrace	6	8	14	
Mulching	7	5	12	
Grass strip	1	0	1	
Plant trees on boundary	4	12	16	
Minimum tillage	1	4	5	
Soil bund	5	9	14	
Stone bund	1	7	8	
Slope of coffee plot				0.25
Gentle	6	17	23	
Medium	13	31	44	
Steep	15	32	47	
Soil depth of coffee plot				0.60
Shallow	9	17	26	
Medium	18	42	60	
Deep	7	21	28	

Source: Survey data (2018)

3.1.4 Asset ownership and institutional characteristics of sampled households'

Cultivated land is the crucial asset, the base of livelihood and means of income source to rural dwellers in Ethiopia. In Ethiopia, cultivated land is distributed through government officials. Sample households are owned 3.4 ha of cultivated land. Adopters of improved coffee varieties have large cultivated land (3.71 ha) and allocated large land for coffee (2.23 ha). Area allocated to coffee production are showed statically significance at 5% and positive effect on the decision to adopt improved coffee varieties with the aim of getting higher yield from a given of

cultivated coffee area. Access to financial institution is one of the institutional factors that affected the sample households' decision to participate on adoption of improved coffee varieties. 55.88% of adopters and only 38.75% of non-adopters were accessed to financial institution. Access to financial institution is showed statistically significance at 10% and positive effect on decision to adopt improved coffee variety. This is due to financial institution supports the agricultural sector by supplying finance to purchase improved agricultural technologies. Educational status of sample household head in class completed was considered as another institutional factor. Educational status of sample household head is showed statistically significance at 1% and positive effect on decision to adopt improved coffee variety. Adopters of improved coffee varieties were completed higher class (9.59) than non-adopters (3.19) and helped to wide their skills and knowledge about the importance and production of improved coffee varieties. Adopters is also showed higher number of extension contact and allocated more cultivated land for other crops. However, these variables did not show statically significance among adopter and non-adopters (table 9).

Table 9 Institutional and asset ownership characteristics of sampled households'

Institutional and social factors	Adopter	Non-Adopter	Total	T-value
Access to Financial institution				2.84*
Yes	19	31	50	
No	15	49	64	
No. of extension contact	18.59	13.68	15.14	1.46
Education status	9.59	3.19	5.10	2.43***
Own land in ha	3.71	3.27	3.4	1.13
Area allocated for coffee	2.23	1.38	1.63	2.99***
Area allocated for other crops	2.31	1.95	2.05	1.10

Source: Survey data (2018)

3.5 Econometric analysis

3.5.1 Identifying co-variant variables contribute to outcome variable before intervention

The covariant variables that could be affected the outcome variables were identified and neglected from further impact estimation based on (Rosenbaum and Rubin, 1983). Based on this, this research has been taken sixteen co-variant variables. Household head sex and area allocated for coffee production affected the decision of smallholder farmers' to participate on improved coffee variety adoption. Household head sex was showed statistically significance at 1% and has negative effect whereas area allocated for coffee was showed statically significance at 10% and has positive effect (Table 10). this is in line with (Diro *et al.*, 2017). During estimation of impact pro-intervention significance variable should be excluded from matching to control their contribution to outcome variables. Based on this, the significance co-variant were excluded.

Table 10 Logistic regression of household participation decision on improved coffee variety

Covariant	Coff	Std.Err	T-value	P-value
HH sex	**-1.51**	**0.56**	**-2.69**	**0.01*** **
HH Age	-0.01	0.02	-0.42	0.67
HH Edu	0.04	0.04	1.1	0.27
Model farmer	0.13	0.32	0.42	0.68
Social contact	0.46	0.44	1.02	0.31
Own phone	0.10	0.38	0.27	0.79
Land in ha	0.04	0.09	0.46	0.65
Saving habit	0.30	0.34	0.88	0.38
Training	0.20	0.30	0.68	0.50
Host demo	0.38	0.89	0.42	0.67
Coffee area	**0.18**	**0.10**	**1.83**	**0.07***
Other area	0.02	0.09	0.26	0.80
No. contact	0.002	0.009	0.26	0.80
Slope	0.14	0.22	0.64	0.52
Depth	-0.25	0.22	-1.17	0.24
SWC	-0.06	0.06	-0.92	0.36
_cons	0.30	1.27	0.24	0.81
Number of Obs. = 114			**LR chi2(16) = 28.55**	
Prob > Chi2 = 0.03			**Pseudo R2 = 20.55**	

Source: Survey data (2018)

*, **, *** Statistical Significance level at 10, 5 and 1% respectively

3.5.2 Estimate the propensity score matching and identifying the common support region

To exclude the influence of some significance co-variant on coffee productivity of smallholder farmers',

significance variables were excluded from matching process and propensity score and common support regions were estimated and identified respectively. Based on this the propensity scores of improved coffee variety producers distributed between 0.0490 and 0.9985 with a mean of 0.4736 whereas the local coffee producers propensity score distributed between 0.0185 and 0.7239 with a mean of 0.2264 (Table 11).

The common support region is identified Based on the two approaches of minima and maxima and trimming approaches (Caliendo and Kopeinig, 2008) . (Leuven and Sianesi, 2018) recommended using both approaches in combination at the same time and gives good matching. Hence, the common support region lies between 0.0.0490 and 0.7239 propensity score. According common support principle off support households' are discarded from matching process. As a result 7 sample households were discarded for further matching process.

Table 11 Distribution of estimated propensity scores

Group	Obs	Mean	Std.dev	Min	Max
Improved coffee producers	34	0.4736	0.2712	0.0490	0.9985
Local coffee producer	80	0.2264	0.1549	0.0185	0.7239
Sample HHs	Off Support	On support	Total		
Adopter	4	30	34		
Non-Adopter	3	77	80		
Total	7	107	114		

Source: Survey data (2018)

3.5.3 Propensity score distribution of the adopter and non-adopters

The estimation of improved coffee variety adoption (propensity scores) for all participants and non-participants were accomplished from propensity of adoption. After identified the common support with the use of improved coffee variety and without use of improved coffee variety , the off supports were discarded from the estimation process and at the last sensitivity analysis was done to check whether the hidden biases affects the estimated ATT or not. As shown in figure 3 the kernel density distribution of propensity scores of the sample households is near to the normal distribution. Both of adopters and non-adopters were found at the left side of the distribution. Generally, figure 3 shows there is wide area of propensity score of adopters similar with the non-adopters of propensity score. it disputed that there is high chance of getting good matches and large number of matched sample size from the distribution as both distribution concentrated at the left and skewed to the left.

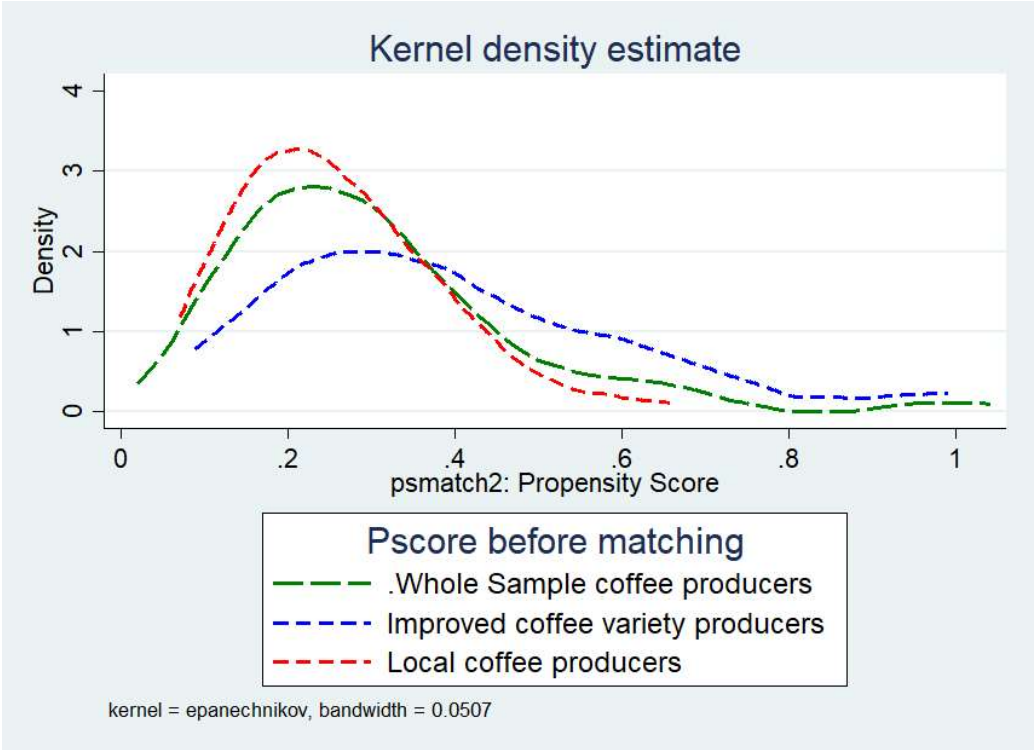

Figure 3 Total Sample Households Kernel density estimation of propensity score

3.5.4 Matching of adopter and non-adopters

The main criteria for determining the common support region is to discarded all observations whose propensity score is smaller than the minimum propensity score of adopters and larger than the maximum of the non-adopters (Caliendo and Kopeinig, 2008). Based on this common support is satisfied in the region of (0.0490-0.7239) for sample households (Table 11). This means that households with estimated propensity scores less than 0.0490 and

greater than 0.7239 are not considered in the matching undertaking. As a result 7 sample households (3 non-adopters and 4 adopters) were discarded and 107 sample households were identified to be considered in the estimation process. Most of the adopter households have propensity scores round 0.3 while majority of the non-adopter households have propensity score round 0.2 (Fig 4, Fig 5).

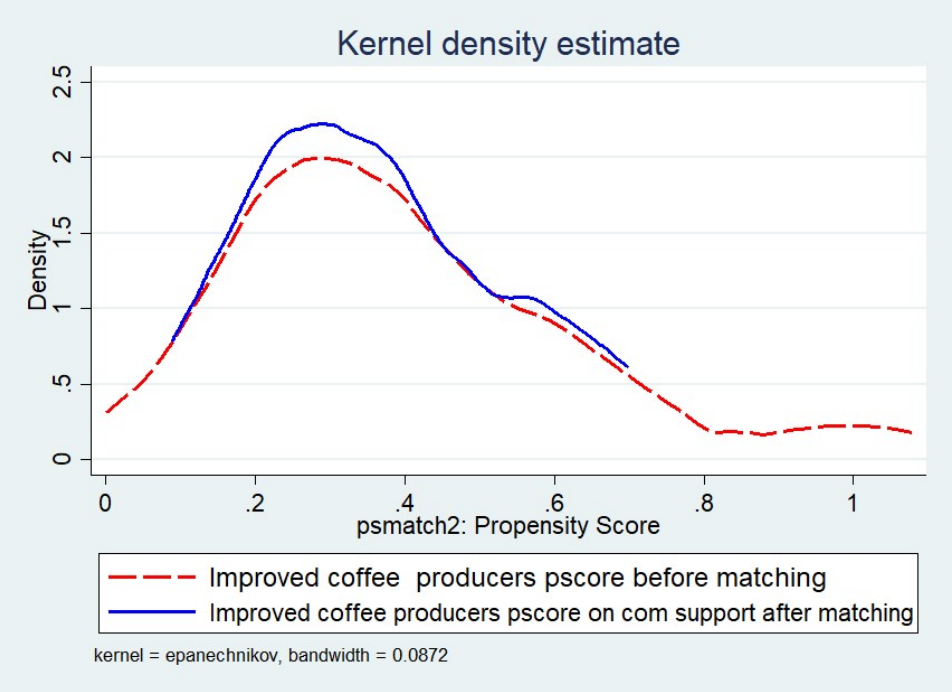

Figure 4 Kernel density estimates of propensity score of improved coffee variety producers before and after matching

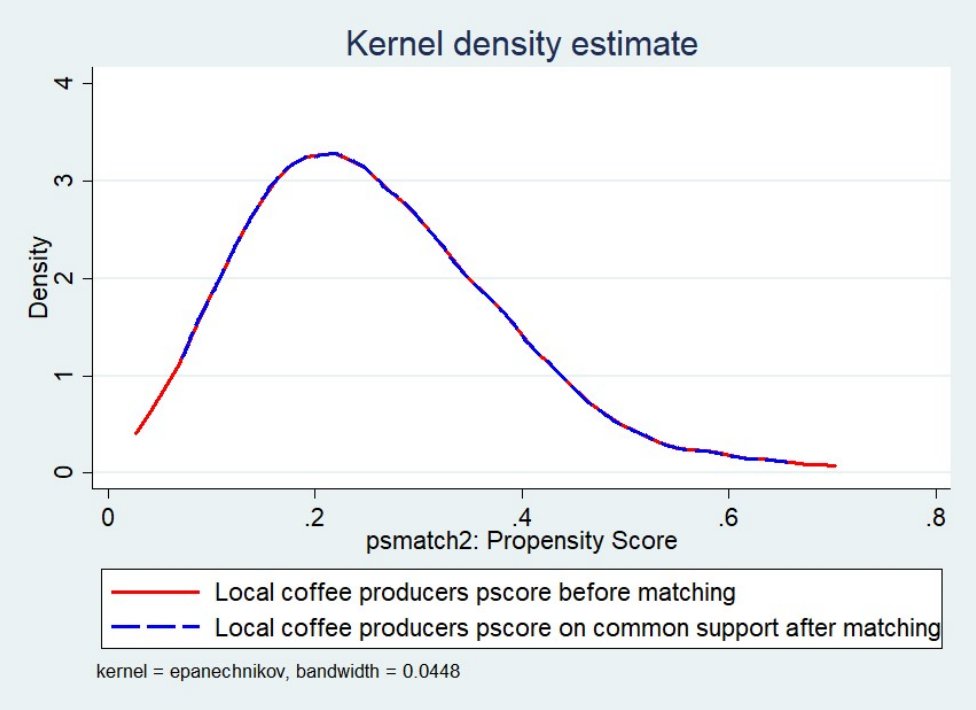

Figure 5 Kernel density estimation of propensity score of Local coffee producer before and after matching

3.5.5 Choice of matching algorism

The relatively numerous insignificant variables (Balancing test), smaller pseudo R^2 value and large matched sample sizes are the criteria to select best matching algorism method. The Method of matching algorism that fulfills all these criteria was chosen as being the estimator of the impact. Except the kernel bandwidth of (0.01), all the matching algorism fulfills all mentioned above. Therefore kernel bandwidth (0.5) has been selected randomly

(Table 12).

Table 12 Performance of matching estimators for sample households

Matching estimator	Performance criteria		
	Balancing Test*	Pseudo R^2	Matched sample size
Kernel Matching			
With 0.01 band width	14	0.1131	77
With 0.1 band width	14	0.1131	107
With 0.25 band width	14	0.1131	107
With 0.5 band width	**14**	**0.1131**	**107**
Radius Caliper Matching			
With 0.01 band width	14	0.1131	107
With 0.1 band width	14	0.1131	107
With 0.25 band width	14	0.1131	107
With 0.5 band width	14	0.1131	107
Neighbor Matching			
1 Neighbor	14	0.1131	107
2 Neighbor	14	0.1131	107
3 Neighbor	14	0.1131	107
4 Neighbor	14	0.1131	107
Sample HHs	Off Support	On support	Total
Adopter	4	30	34
Non-adopter	3	77	80
Total	7	107	114

Source: Survey data (2018)

*Indicates number of insignificance variables

3.5.6 Testing the balance of propensity score and co-variant

After choosing the best performing matching algorism of kernel bandwidth (0.5), the next task is to check the balancing of propensity score and co-variant. The T-test suggests that the differences in household characteristics between the adopter and non-adopters are jointly insignificance both before and after matching. The main purpose of the estimation of propensity score is to balance the distribution of the relevant variables in both adopter and non-adopters. Table 13 showed that all co-variant after matching are insignificance which indicates that the balance test was well balanced.

Table 13 Balancing Test of Matched sample

Covariant	Before Matching(114)			After Matching(107)				
	Adopter (34)	Non-adopter (80)	T-test	Adopter(30)	Non-adopter (77)	Bias	T-Test	P>t
HH Age	44	43.88	0.05	42.77	42.85	-0.8	-0.03	0.97
HH Edu	9.58	2.62	1.74	3.97	3.33	3.8	0.73	0.47
Model farmer	0.47	0.47	-0.00	0.47	0.38	18.6	0.71	0.48
Social contact	0.24	0.12	1.27	0.20	0.11	24.5	0.97	0.48
Own phone	0.79	0.82	-0.30	0.77	0.74	7.4	0.28	0.78
Land in ha	3.71	4.35	-0.94	3.80	3.32	25.5	0.95	0.35
Saving habit	0.56	0.41	1.21	0.57	0.42	30.2	1.16	0.25
Training	0.56	0.50	0.48	0.5	0.43	14.4	0.55	0.59
Host demo	0.03	0.06	-0.58	0.03	0.03	2.9	0.11	0.92
Other area	2.31	2.12	0.43	2.27	1.99	16.6	0.63	0.53
No. contact	18.59	24.90	-1.33	16.93	14.45	14.9	0.58	0.56
Slope	2.27	2.21	0.37	2.30	2.22	10.5	0.40	0.69
Depth	1.94	1.71	1.47	1.97	1.99	-4.8	-0.18	0.86
SWC	2.38	2.71	-0.53	2.67	2.24	1.0	0.04	0.97

Source: Survey data (2018) *, **, *** Indicates significance at 10, 5, and 1% respectively

3.5.7 Treatment Effect on the treated (ATT)

Average treatment effect (ATT) estimation using kernel matching method with bandwidth of (0.5), summarized the coffee productivity generated due to adoption of improved coffee variety (Table 14). The result indicated that average treatment effects of adopters were produced 6.18 equivalents to 724 kg/ha of coffee yield while the non-adopters were produced 5.82 equivalents to 440.92 kg/ha, indicating that the average coffee productivity of adopters are greater than the average coffee productivity of non-adopters produced coffee per hectare. The result shows the propensity of adoption decision of improved coffee has positive effect and statistically significance

difference between adopters and non-adopters in terms of coffee product produced per hectare. In general, smallholder decision of adopting improving coffee variety has brought 64.20% increment in coffee production over non-adopters. This paper conclude, adoption of improved coffee varieties have positive effect on increasing coffee productivity of smallholder farmers from similar cultivated farm land in the study area. The result is in line with finding of other researchers on the impact of soybean adoption by (Kedir *et al.*, 2017), Impact of high yielding wheat variety adoption (Dibaba and Goshu, 2018), impact of food security package loan on food insecure households' income and asset creation by (Tesfay *et al.*, 2018) and (Welay Tesfay; Desalegn, 2019), Impact of Improved Soybean Variety on Enhancing Productivity and Gross Farm Income of Smallholder Farmers in North Western Ethiopia

Table 14 Estimate of average treatment effects on coffee yield of Household

Outcome variable	Sample	Treated	Controls	Difference	SE	T-stat
Coffee yield	Unmatched	738.82	430.56	308.26	89.75	3.43
	ATT	724	440.92	283.08	123.38	2.29***
	ATU	438.90	705.60	266.71		
	ATE			271.30		
Log Coffee yield	Unmatched	6.24	5.80	0.44	0.16	4.05
	ATT	6.18	5.82	0.36	0.14	1.87*
	ATU	5.82	6.14	0.32		
	ATE			0.33		

Source: Survey data (2018). *, **, *** Indicates significance at 10, 5, and 1% respectively

3.5.8 Sensitivity of the estimated average treatment effects (ATT)

The sensitivity analysis is tested to check whether the unobserved co-variant have effect on impact of coffee productivity of smallholder farmers due to improved coffee variety intervention. Sensitivity analysis is the final diagnostic that performed to check the sensitivity of the specification of the propensity score (Dehejia and Wahba, 2002). Moreover, sensitivity analysis was undertaken to detect the identification of conditional independence assumption (CIA) and was satisfactory or affected by the con-founder. According the test in (Table 15) ATT effect of coffee productivity due to adoption of improved coffee variety was not affected by con-founders. The significance level is also unaffected even if the gamma value are relaxed in any desirable level, shows that ATT is insensitivity to external change.

Table 15 Sensitivity analysis of the estimated ATT

Gamma	Sigma (σ+)	Sigma (σ-)
1	0	0
1.25	1.1e-16	0
1.5	1.9e-14	0
1.75	1.2e-12	0
2	2.8e-11	0
2.25	3.2e-10	0
2.5	2.3e-09	0
2.75	1.1e-08	0
3	4.4e-08	0

Source: Survey data (2018)

4 Summaries and Conclusion

The study was conducted at Wombera district, Metekel Zone, Benshangul Gumuz National Regional state, in North western Ethiopia, with the purpose of determining the factors that affected the adoption of improved coffee variety and its impact on coffee productivity at smallholder coffee producers'. The descriptive statistics result revealed that adopter of sample households are relatively higher in Bolelie Keble, older, more social network, obtained training, construct different soil and water conservation methods, access to financial service, high extension contact, complete higher class, owned large land and allocated large land for coffee and other crops than non-adopters. However, adopters were hosted lower demonstration than non-adopters. It also indicated that adoption rate of improved coffee varieties is 29.82% and 40.67% in terms of respondent response and area coverage under improved coffee variety respectively.

The result of logit regression revealed that household head sex and area allocated for coffee production was the main factors that determined improved coffee varieties adoption in the study area. Area allocated for coffee production has statistically significance and positive effect whereas household head sex has statistically significance and negative effect on the improved coffee variety adoption decision.

The Propensity score matching (PSM) result showed that adopters of improved coffee variety were recorded

higher impact over non-adopter in terms of coffee output produced. Adopters of improved coffee variety were produced higher coffee output than the non-adopters. Adopters were produced 724 kg per hectare of coffee which is higher than the non-adopters produced 440.92 kg per hectare. The result indicated that Adopters were produced 283.08 kg per hectare of coffee on average over the non-adopters due to the adoption of improved coffee variety. The finding of this paper indicated that adopter of improved coffee variety has been brought 64.20% of increment in coffee production over the non-adopters as being adopter of improved coffee variety. In general, adoptions of improved coffee varieties are means of coffee output increment and securing economic welfare of smallholder farmers. Therefore, GO and NGO authorities should be focused on the expanding and disseminating of these improved coffee varieties over the coffee pro agro-ecologic of the country.

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