Innovations

Assessment of the Impact of adoption of improved maize variety on commercialization using Propensity Score Matching

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Abstract

Commercialization of agricultural output, generally speaking, refers to an economic behaviour of farmers whereby theyare engaged in selling their agricultural produceregardless of giving prime importance to meet their own need for consumption. Rural farm households, at subsistence level, also participate in commercialization by supplying certain proportion of their output to the market to make some of their ends met. The underlying assumption of the study is that small holder farmers differ in their decision of commercialization and it is quite intuitive that improved seed matters a lot in this regard. Thus the study attempted to reveal, empirically, whether or not adoption of improved maize seed matters a lot insofar as commercialization is concerned. To this end the study used primary data from a randomly selected 223 rural farm household heads from Boricha woreda.The Average Treatment effect on the Treated (ATT) unveiled that adoption of improved maize varieties positively and significantly affected the level of commercialization.

Key words: 1. Commercialization 2. Maize 3. Impact 4. Propensity Score Matching

1. Introduction

commercialization of agricultural output is the process where by farmers are engaged in producing primarily for sale in nearby or distant markets without giving prime importance to meet their own need for consumption. In this case commercialization entails a process of involving alteration of the goal of agriculture to market oriented production whose consequence is paramount in terms of income, consumption and widening the choice matrix of the rural household. (Shukla, 2016;Kassa et al 2014).

Be this as it may however, farm households at subsistence level also participate in commercialization by supplying certain proportion of their output to the market from their subsistence level. In this research, however, an attempt has been made to study the impact of adoption of improved seed on the level of commercialization of rural households of their farm produce of maize whose prime production is subsistence. Even though the prime goal of maize production is for subsistence level, there still exists some level of commercializing involved among rural farm households. The underlying assumption of the study is that small holder farmers differ in their decision of commercialization and that may be greatly attributable to whether or not they are using improved maize seed. The causes of the diversity are attributable to various demographic, social, economic, or institutional factors and also whether or not rural farm households are using an improved seed.(Kinuthia and Mabaya ,2015; Bekele et al 2014;Gebremedhinet al,2007)

While keeping the question of commercialization intact, the study delves into pondering over on the impact of adoption of improved maize variety on commercialization. Thus an attempt is made to uncover as to how adoption is impactful in so far as commercialization is concerned pertaining to small holder rural farm households by so looking at impact using Propensity score matching method.

2.Impact assessment tool: Propensity score matching

Propensity score matching is able to address possible problems of selection bias which could possibly arise from the very fact that the treatment variable (improved maize seed) could have been adopted non randomly by the farmers; it could also be the case that market participation could have happened non randomly too. This may intern make the process of attributing the impact of commercialization of maize produce solely to improved seed a difficult research exercise. (Bryson et al., 2002; Ravallion, 2005; Rosenbaum and Rubin, 1983)

The strength of propensity score matching as a prominent tool of impact assessment is that it helps us to conduct somewhat something fairly similar to randomized experimental approach which is carried out by identifying a comparable group(non adoptors of improved seed) which is identical in every way to the treatment group (adoptors of improved maize seed)

3. Mathematical specification of Propensity score matching

When we come to the mathematical specification of the propensity score matching method, estimating the impact of farm households' adoption of improved maize decision on outcome variable oflevel of commercializationcan be specified as(Bryson et al., 2002):

$$\tau_i = Y_i(D_i = 1) - Y_i(D_i = 0) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

Where τ is treatment effect or impact that is attributable to adoption decision, Y is the outcome variable, level of commercialization, on farm household, D is whether household has got the treatment or not (i.e., whether a household adopted improved maize variety or not). Itshould be underlined, however, that adopters and non-adopters,$(Di = 1)$ and $Yi(Di = 0)$, respectively, cannot be observed for the same farm household at the same time because a given farm household cannot be both an adopter and a non-adopter at the same time. This is really why the task of an impact assessment is a difficult research endeavour as estimating individual treatment effectis animpossibility.

A general solution for this problem is the average treatment effect (ATE). There are two types of average treatment effect. One is the Averagetreatment effect (ATE) which can be, mathematically, computed as the difference between the expected outcomes of adopters and non-adopters, the second one is, which isthe most plausible, Average Treatment Effect on the Treated (ATT), that tries to singleout the effect of adoption only on the adopters.

The mathematical formulation of the average treatment effect (ATE) can be depicted as:

$$\Delta Y_{ATE} = E(\tau_i) = E(\Delta Y) = E(\Delta y_1) - E(\Delta Y_0) \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

The average treatment effect (ATE) tries to measure the expectation of the impact of adoption of improved maize seed on commercialization across all rural household farmers. Using the above equation as a tool ofestimating impact assessment is problematic. The basic source of the problem is our data is not experimental data. The non-experimental cross sectional data that we have reveals only adopters or non-adopter at a given point in time. We, thus, need to resort to Average Treatment effect on the Treated (ATT) which is mathematically depicted as:

$$\text{ATT} = \Delta \text{Y}_{\text{ATT}} = \text{E}(\tau/\text{D} = 1)\,) = \text{E}(\text{Y}_1/\text{D} = 1) - \text{E}(\text{Y}_0/\text{D} = 1) \ldots \ldots \ldots \ldots \ldots \ldots ..(3)$$

Equation (3) above answers the question as to how adoption of improved maize variety impacted the commercialization level of adopters compared with non-adopters. Obviously outcome data on adopters $\text{E}(\text{Y}_1/\text{D} = 1)$ is available but outcome data on non-adopters$\text{E}(\text{Y}_0/\text{D} = 1)$ is not available for the same farm household.

This necessitates the choice of a reasonably acceptable substitute. Due to this problem, one has to choose a proper substitute; hence the question of matching pops in, so much sothat predicting ATT is possible.

In order to do that we employ the average outcome of the outcome variable (commercialization) of non-adopters as a proxy for the mean of the counterfactual group of adopters having, first, accounting for the problem of selection bias.

To do that equation (3) can be re formulated as

$$\text{ATT} = \tau_{\text{ATT}} = \{[\text{E}(\text{Y}_0/\text{D} = 1) - \text{E}(\text{Y}_0/\text{D} = 0)] - [\text{E}(\text{Y}_1/\text{D} = 1) - \text{E}(\text{Y}_1/\text{D} = 0)]\} \ldots ..(3)$$

In the above equation both terms in the left hand side and right hand side are observables. Furthermore in the equation (3) above ATT is identifiable and can be estimated providedthat there is no self-selection bias i.e. $\text{E}(\text{Y}_0/\text{D} = 1) - \text{E}(\text{Y}_0/\text{D} = 0) = 0$. For this to hold true, two prominent assumptions should be explicitly stated and duly satisfied inorder to insure that self-section problems are accounted for. These are Conditional Independence Assumption (CIA) and Common support region assumption.(Rosenbaum and Rubin, 1983)

1. Conditional Independence Assumption (CIA)

Conditional Independence Assumption can be expressed as:$\text{Y}_0 \perp \text{D} \;/\; \text{X}$

Where $\perp$ refers to independence and X is a set of observable characteristics, and Y_0 is non-adopters. Conditional independence assumption refers to the equation that for a given set of explanatory variables or covariates (Xi) are assumed to be not affected by the treatment variable (i.e. Adoption of improved maize variety). This means the outcome variable (commercialization) should be independent of treatment variable i.e. the levels of commercialization are not affected by treatment. The implication of this assumption is adoption decision is solely based on observable covariates (ii) and determinants of adoption and levels of commercialization are observable simultaneously. (Caliendo and Kopeinig, 2008)

Now that the observable differences are adjusted the average outcome for both groups of adopters and non-adopters is the same or comparable, i.e. $\text{E}(\text{Y}_0/\text{D} = 1\,, \text{X}) = \text{E}(\text{Y}_0/\text{D} = 0, \text{X})$

It is in this way that PSM, given covariates, solves the problem of selection bias. The distribution of observables, at the end of the day, will be similar for both groups of adopters and non-adopters now that the propensity score is a balancing score

II. Common support region assumption

The second assumption relates to the common support or overlap condition. This refers to the law of probability being satisfied for both groups. The common support region rules out the perfect predictability of D for a given values of X. Mathematically, it is expressedas

$$0 < P(D = 1 / X) < 1$$

This condition guarantees that farmers with the same covariates of X values have a positive probability of being both an adopter and a non-adopter. This makes Average Treatment Effect (ATE) is only identified with in the rubric of the common support.Farm households who are not with in the common support region are not included in the estimation of the ATE.On condition that the two assumptions are satisfied, the propensity Score Matching(PSM) estimator of the Average Treatment effect on the Treated (ATT) can be expressed as

$$ATT = \tau_{ATT}^{PSM} = \{E[Y(1)/D = 1, P(X)] - E[Y(0)/D = 0, P(X)]\} \dots\dots\dots\dots\dots\dots\dots\dots (4)$$

Thus according to the above equation (4), one can safely estimate the impact ofadoption of improved maize variety on the level of commercialization by simply taking thedifference of the average level of commercialization of the two groups.

4. Sampling technique, Sample size and Data type

The study applied multi stage sampling technique where by credible sampling technique is employed in each and every stage. In the first stage Boricha Woreda, the study area, was purposively selected. In the second stage kebeles from different agro ecological zones of the study area are selected based on stratified random sampling. In the third stage farm household heads from the different kebeles are selected randomly. The study adopted Yamane's, (1967) sample size determination formula. Accordingly a cross sectional survey was conducted on a sample of 223 rural farm household heads from Boricha woreda

5. Instrument of Data collection

Questionnaire was used as a primary tool for collecting data from the house hold head at stake. The questionnaire contained many close ended and some open ended items. Moreover, the questionnaire was prepared, commented and pilot tested to make sure that reliable and authentic data was collected.

6. Measuring the level of commercialization

This study has employed the household commercialization index (HHCI) to determine household specific level of commercialization. The index measures the ratio of the grossvalue of sales of a given crop (maize, in our case) by household i in year j to the gross value of all cropsproduced by the same household i in the same year j expressed as a percentage.(Gebreselassie and Ludi, 2008). Accordingly the level of commercialization can be represented as:

$$HHCIM_i = \frac{\text{gross value of maize sales}}{\text{gross value of total crop production}} * 100 \dots\dots\dots\dots\dots\dots\dots\dots (5)$$

Where HHCIM house hold commercialization index of the i^{th} maize farmer. The index is only used to measures the extent to which household crop production is oriented toward the market. A value of zero would signify a totally subsistence oriented household and the closer the index is to 100, the higher the degree of commercialization

7. Result and discussion

The Propensity Score Matching (PSM) estimation of average treatment effect on the treated analysis as revealed in the table below is based on the threealternative matching methods namely: nearest neighbour, radius and kernel matchingmethods. The outcome variable is the level of commercialization as measured as in equation (5) above. The average treatment effect on the treated, as discussed above,is the safest way of estimating the impact ofadoption of improved maize variety on the level of commercialization by simply taking thedifference of the average level of commercialization of the two groups as it solves the problem of selectivity bias and non-randomness of the adoption decision.

Table 1: Result of Average Treatment Effect on the Treated

Outcome variable: level of commercialization							
Treatment variable : Adoption of improved maize variety							
Algorithm	Common Support						
	Off support		On support		ATT	SE	t-value
	Adoptors	Non adoptors	Adoptors	Non adoptors			
Nearest Neighbour(1)	0	0	129	74	0.22	0.21	0.10
Nearest Neighbour(5)	0	0	129	74	0.33	0.06	2.94***
Radius Matching(0.057)	0	0	129	74	0.44	0.02	9.35***
Radius Matching(0.087)	0	0	129	74	0.44	1.06	9.35***
Kernel(0.05)	127	0	2	74	0.11	0.16	0.07
Kernel(1)	0	0	129	74	0.36	0.06	2.70***

Source: Own Survey and computations, * significant at 1%**

The Average Treatment effect on the Treated (ATT) is estimated using equation (4) of the above discussion. Accordingly the results unveiled that adoption of improved maize varieties positively and significantly affected the level of commercialization in favour of adopters. This, however, is not true for all types of matching algorithm and band width. ATT rangesfrom 44% in the case of radius matching to 11% to kernel matching of band width (0.05), but the kernel one is not significant. In the entire matching algorithm, adopters are better-off than non-adopters. In the case of nearest neighbour matching of (1) band widthadopters are better-off than their counter parts by 22 %.That means the level of commercialization of adoptors is 22% greater than that of non adoptors and this difference, however, isnot statistically significant. The difference, in favour of adopters, increases to 33 % for the same matching algorithm but a band width of (5) and the difference is, in this case,significant at one percent level of significance. When we come to radius matchingalgorithm, no distinction is observed be it in terms of level of difference or in terms of statistical significance. In both Radius matching algorithm of (0.057) band width and Radius matching algorithm of (0.087) band width adopters are better off than non-adopters by 44% level of commercialization and the difference is significant at one percent level of significance. With respect to kernel matching algorithm of band width (1) adopters' level of commercialization is greater than non-adopters by 36% and this difference is significant at one percent level of significance. For Kernel matching of band width (0.05) the difference, though, statistically significant, dwindles to 16%.

In conclusion four matching algorithms out of six unveiled that adoption ofimproved maize variety significantly contributed for the enhancement of the level ofcommercialization by farm households. This implies that, according to equation (4) of the above discussion and under the condition that there is no selection bias due to unobservablefarm household head characteristics, the outcome variable of the level ofcommercialization for adopters is significantly higher than the non-adopters.

One important observation in this case of propensity score matching with respect tocommercialization is that, though there is significant impact, the impact is notquantitatively large. The fact that the difference is not quantitatively pronounced can beattributed to the reason that the rural households, in general and also in the study area, are all primarily engaged in subsistence agriculture.This is because, ceteris paribus, what is made available for commercialization iswhat is left over and above households' personal consumption.

8. Implication

The study has unveiled that adoption of improved maize seed has a statistically significant impact on the level of commercialization. Therefore, the more the rural community is capacitated to adopt the improved maize seed the greater the level of commercialization and the higher the derived benefit from it. Thus the study recommends that both formaland informal systems of enhancing farmers' ability of adoption should be well thought of as a vehicle of enhancing commercialization of farm output and there by transforming the rural household.

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