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ARTICLES

Impact of Dairy Co-operative Society on Adoption of Improved Farm Practices: A Farm Level Experience in Assam

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ABSTRACT

The study makes an attempt to estimate the impact of becoming member of dairy co-operative society (DCS) on adoption of improved and production augmenting farm practices such as fodder cultivation, adoption of artificial insemination (AI) and concentrate feeding among dairy farmers in Assam. As simple comparison between members and non-members of DCS on the impact indicators may be embedded with selection bias and may not give accurate estimates, the study has used propensity score matching to address selection bias based on observed covariates. Relying on information from a sample of 202 smallholder dairy farmers and by estimating the average treatment effects on the treated (ATT), the study has shown that members of DCS are significantly found to practise fodder cultivation, adopt more AI and feed more amount of concentrates to their animal. Given that these impact indicators of becoming members of DCS may have productivity enhancing effect, the co-operative system of dairying in the state needs to be strengthened to develop the dairy sector of the state.

Keywords: Dairy co-operative society, Improved farm practices, Impact, Propensity score matching, Assam.

JEL: Q12, Q13.

I

INTRODUCTION

Policies, besides targeting to improve productivity and overall production of the small and marginal farmers, providing better access to market has been an important element in the strategies to ensure rural development and poverty reduction. According to FAO (2012), a strong co-operative provides a range of services to its members that include access to natural resources, information, communication, input and output markets, technologies and training. Dairy co-operative society is considered an important medium for distribution of milk and technological innovations and thus membership of DCS may positively affect the adoption of certain improved farm technologies. Studies point out that the smallholder farmers face marketing constraints which impede them from exploiting the benefit of market opportunities (Fischer and Quaim, 2012). These constraints sometime become more severe for perishable commodities like milk. Large scale milk handling in the unorganised sector stresses the importance of dairy co-operative society (DCS) as

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vital channel for the marketing of milk, its potential role to increase production and reduce cost of procurement, processing and marketing of dairy products through economy of scale approach (Rangasamy and Dhaka, 2008). In the Indian context, DCS, besides providing an assured market for milk, also provide inputs and services like credit to the member-producers (Taneja and Birthal, 2005). Over the years, the role of dairy co-operatives are conceived as the major driving force for the success of white revolution and country's increased milk production to the tune of 155.49 million tonnes during 2015-16 from a production as low as 17 million tonnes during 1950-51. Presently, dairy co-operatives collectively procure 15.58 million tonnes of milk accounting for 10 per cent of the total milk production in the country indicating the importance of dairy co-operatives in India (NDDB, 2016). The impact of taking membership of dairy co-operatives on raising production, marketing and other farm performance indicators are well documented (Kumar *et al.,* 2013; Bardhan and Sharma 2012; Chagwiza *et al.* 2016). Studies in other parts of the world show the impact of agricultural co-operatives on the adoption of improved farm practices. In the Ethiopian context, Abebaw and Haile (2013) showed that membership of agricultural co-operatives had impact on fertiliser adoption; while, Verhofstadt and Maertens (2014) in Rwanda found a significant impact of co-operative membership on the probability of farmers to adopt mineral fertiliser and improved seeds. However, there is paucity of studies to show dairy co-operative's role in the adoption of improved farming practices which are production augmenting in nature.

Dairy co-operatives handling milk along with the number of member-producers in Assam has increased significantly during 2000-01 to 2015-16. The daily milk procurement by co-operatives was 3,000 litres with only 1000 member-producers in 2000-01 which increased to 22000 litres with 16000 member producers during 2015-16 (NDDB, 2016). The expansion of dairy co-operative sector in Assam may also bring other associated impacts on the farmers along with increased marketed surplus, income, employment, etc. In a recent study, Bayan (2018) has emphasised on the positive impact of DCS membership on increased farm performances of smallholder dairy production system. The present study is thus focused on identifying the role of DCS on the adoption of improved farming practices such as fodder cultivation, adoption of artificial insemination (AI) and feeding concentrate to the animal. These outcome variables are of particular importance in the context of Assam due to its embodied potential to augment dairy production concurrently with grade cattle adoption. Furthermore, the outcome variables are specifically linked to the understanding that declining area under pasture land and lack of fodder cultivation practices among farmers has stood as a major challenge for dairy development in the state. The area under fodder cultivation in the state is only 0.15 per cent of the total cropped area against the all India average of 2.29 per cent (Feroze *et al.,* 2010). Again, AI being an important and economically viable technique of cattle crossbreeding, its coverage of breedable cattle population is still abysmally low (reflected in only 3.84 per cent crossbred cattle population) in Assam even though AI was started way back in 1970s with the launch of Intensive Cattle Development Project (ICDP). Similarly, feeding concentrate to the animal is also quite low in the state even though studies point out its importance to raise productivity.

In order to control for selection biases arising from simple comparison of members and non-members of DCS on their outcome variables, the study has used propensity score matching (PSM henceforth).[1] PSM is a widely used semi-parametric technique for impact evaluation of programme participation (DCS membership status in our case). The study is organised in four sections including the introduction. Section II discusses materials and methods used in the study. While, Section III presents the results and discussion of the study, Section IV finally concludes the paper.

II

MATERIALS AND METHODS

Data

The study was conducted in three districts of Assam, namely, Barpeta, Sonitpur and Karbi Anglong for a data set of 245 smallholder dairy farmers. Multistage sampling techniques was followed for selecting the sample farmers for the study. In the first stage, districts were stratified into high, medium and low in terms of AI coverage of breedable cattle population and crossbred cattle population density per hundred hectares of geographical area. Following this, one district was randomly selected from each stratum with Barpeta belonging to high, Sonitpur to medium and Karbi Anglong to low stratum. In the second stage, two representative community development blocks (CDB) were chosen from each district with the understanding that one CDB has high and the other with a relatively low AI coverage and crossbred cattle density. Some key informants in the district; such as district veterinary officer (DVO), and block veterinary officer (BVO) and veterinary officers (VO) in the block and state veterinary dispensary guided the selection process of the CDB. In the third stage, three sample villages from each CDB were selected considering that the villages have sizable number of crossbred cattle and AI coverage of breedable cattle population. Finally, 30 per cent sample farmers from each village were selected and interviewed using systematically designed and pre-tested questionnaire.

The farm locations were filtered in terms of availability of at least one active dairy co-operative society (DCS) with the farmer’s likelihood of being member/non-member of that DCS. Farm location that did not have a DCS with the understanding that spatial distribution of those farmers may not be influential to take membership of DCS were dropped from the original data set. Thus 202 farmers were the ultimate sample size with co-operative membership status (74 members and 128 non-members) as the target variable.

Method: Propensity Score Matching

The present study has used propensity score matching method to assess the impact of DCS membership on adoption of three improved farm practices, namely, fodder cultivation for feeding the farm animals, adoption of AI and concentrate feeding. Following Rosenbaum and Rubin (1985) and Gitonga *et al.* (2013) the whole estimation strategy of impact evaluation using PSM is based on two stages. In the first stage, estimation of conditional probability of being member of DCS or propensity score is carried out using a Probit model based on pretreatment characteristics.[2] The propensity score equation is of the following form:

$$p(X) = \Pr[Z = 1 \mid X] = E[Z \mid X]; \quad p(x) = F\{h(X_i)\}, \qquad \text{....(1)}$$

where F{.} can be cumulative distribution function for X which is a vector of pre-treatment characteristics (Becerril and Abdulai, 2009). Propensity score is a single index variable that addresses dimensionality problem arising due to the heterogeneity between the set of observables of both members and non-members of DCS.

In the second stage, members and non-members are matched on their propensity score using commonly applied matching algorithms such as nearest neighbor matching (NNM), Kernel based matching (KM) and radius matching (RM).[3] In NNM, each observation in the control group (non-member) is matched to one or more observations in the treatment group (member) based on their closest propensity score. In KM, each observation in the treatment group is matched to weighted averages of individuals who have similar propensity score. Radius matching takes into account tolerance level on the maximum propensity score distance between an observation in the treatment group and entire observations in the control group who are within that distance (Chen and Zeiser, 2008; Gitonga *et al.*, 2013).

The main purpose of PSM is to balance the distribution of observable covariates of the two groups (members and non-members of DCS) to ensure that there is overlap (no systematic difference in the distributions) (Lee, 2008). The preconditions for a matched sample between groups are: (i) two sample *t*-test for each observation indicating that after matching there is no systematic difference; (ii) comparison of pseudo R^2 and joint significance of covariates (*p*-values of likelihood ratio test) indicating that after matching the pseudo R^2 should be lower and the joint significance of covariates should be rejected (*p*-values should be insignificant (Sianesi, 2004); (iii) following the reduction of mean absolute standardized bias (MASB) approach (Rosenbaum and Rubin, 1985) which suggests that standardised bias of greater than 20 per cent is found to be considerably large and an indicator that the matching process has failed; and (iv) finally, check common support or overlap visually using propensity score graph ('psgraph' command in STATA 14).

Fulfilling the conditions of matching, the average treatment effects on the treated (ATT) are computed after dropping the observations that lie outside the common support or overlap regions as follows:

$$ATT = E(Y_1 - Y_0/Z_t = 1) = E(Y_1/Z_t = 1) - E(Y_0/Z_t = 1) \quad ....(2)$$

where, Y_1 and Y_0 are the outcome variables of our interest in the treated and control states respectively; and Z_t is an indicator variable (treatment status) pointing out membership of DCS. However, PSM has the limitation that it fails to control selection bias arising from unobserved variables such as risk perceptions, motivations, etc. Nevertheless, it is a good method and used extensively to evaluate the impact of programme participation, as it is based on counterfactual approach of causality and avoid selection bias arising from systematic differences between treated and control group on their observed variables.

III

RESULTS AND DISCUSSION

Descriptive Results

Table 1 presents the choice of outcome and explanatory variables and their definitions and measurement. The outcome variables of our interest being fodder

TABLE 1. VARIABLE DEFINITION AND MEASUREMENT

Variable (1)	Type (2)	Definition (3)	Measurement (4)
Outcome variables			
Fodder cultivation	Dummy	If the farmer had cultivated Napier or Oats variety grass during 12 months preceding the survey	1 if yes, 0 otherwise
Adoption of AI	Dummy	If the farmer had adopted AI as breeding method during 12 months preceding the survey	1 if yes, 0 otherwise
Concentrate feeding	Continuous	Amount of concentrate fed per litre of milk	grams
Explanatory variables			
Age	Continuous	Age of household head	Years completed
Education	Continuous	Number of years in school	Years completed
Family size	Continuous	Total household members	Numbers
Herd size	Continuous	Total number of cattle in the farm	Numbers
Distance to all-weather road	Continuous	Distance from the farm to the nearest all-weather road.	Metre
Access to Credit	Continuous	If the household accessed credit during 12 months preceding the survey	1 if credit accessed, 0 otherwise
Beneficiary of govt. dairy development programme	Dummy	Farmers ever benefitted from any dairy development programme during 12 months preceding the survey	1 if beneficiary, 0 otherwise
Extension	Continuous	Average number of times the farmer met the extension agent during 12 months preceding the survey	Years completed
Financial inclusion	Dummy	Whether the farmer has a bank account during the survey	1 if yes, 0 otherwise
Price of milk	Continuous	Average price received for the milk sold	Rs.

Source: Author’s own definition.

cultivation, adoption of AI and concentrate feeding may play a vital role in enhancing productivity and overall milk production in the state. The selection of the explanatory variables, likely to influence the membership of DCS, was guided by previous studies (Chagwiza *et al.,* 2016; Ma and Abdulai, 2016; Mojo *et al*., 2017; Bardhan and Sharma, 2012).

Description of the data on demographic and socio-economic characteristics and improved farm technologies collected through primary survey questionnaire is presented in Table 2. The households are categorised into member (treatment) and non-members (control) of DCS in which 36.63 per cent are members and 63.37 per cent are non-members (Table 2).

TABLE 2. DESCRIPTIVE STATISTICS FOR OUTCOME AND EXPLANATORY VARIABLES OF UNMATCHED SAMPLE (MEAN)

	Treatment (N=74)		Comparisons (N=128)		*t*-test (2-tailed)
Variables (1)	Mean (2)	Std. error (3)	Mean (4)	Std. error (5)	Difference (6)
Fodder cultivation	0.6081	0.0571	0.0876	0.0242	0.5205***
Adoption of AI	0.9459	0.0265	0.2920	0.0390	0.6540***
Concentrate feeding	400.3013	0.1969	227.0993	0.1249	173.202***
Age	51.5135	1.3783	50.2920	1.0868	1.2215
Education	8.5946	0.5072	5.1241	0.3790	3.4705***
Family size	5.7973	0.3208	5.7226	0.1901	0.0747
Herd size	6.6892	0.6698	6.8905	0.6952	0.2013
Distance to all-weather road	310.8243	44.4030	421.8978	32.7134	-111.0735**
Access to credit	0.2703	0.0519	0.0876	0.0242	0.1827***
Beneficiary of government dairy development programme	0.5000	0.0585	0.0511	0.0189	0.4489***
Extension	15.5811	1.5786	5.0438	0.5226	10.5373***
Financial inclusion	0.9054	0.0343	0.6788	0.0400	0.2266***
Price of milk	32.2838	0.8133	32.8832	1.0446	- 0.5994

Source: Author's estimation based on field survey data.
Note: *** Significant at 1 per cent.

The members and non-members of DCS appear to be similar in terms of their age, family size, herd size and price of milk, but have significant difference on the remaining variables. For example, members have higher years of schooling compared to non-members. The average years of schooling of members is 8.6 years against 5 years for non-members. Members have better access to road infrastructure as average distance to all-weather road for members is less by 111 metres from the non-members counterpart. Members are significantly better-off in terms of accessing various institutional services such as access to credit, beneficiary of dairy development programme and financial inclusion by an average margin of 18.27 per cent, 44.89 per cent and 22.66 per cent respectively compared to their non-members counterpart. The average number of times the members met the extension personnel during the year preceding the survey is about 15 vis-à-vis only 5 for non-members.

Table 2 also shows that with respect to the outcome variables members are better-off compared to their non-members. However, these differences are not sufficient to draw inferences of positive impact of DCS on the adoption of productivity raising farm practices. The confounding factors need to be controlled and thus PSM technique is the way forward to estimate the impact.

Determinants of Co-operative Participation

Probit regression results, in which the DCS membership status (1=member; 0=otherwise) was regressed on baseline characteristics, are presented in Table 3. As a first step of PSM, the probit model equation (Eq. 1) estimates the propensity of becoming member of DCS for each household. The joint statistical significance of explanatory variables (LR χ^2 test statistics = 101.15, *p*-value =0.000) indicate a good fit of the model. The pseudo R^2 (0.3700) also implies a good model fit as pseudo R^2 falling in the range of 0.2 to 0.4 is considered to indicate so (Elder *et al.,* 2012). The results of the probit regression show that membership of a DCS is significantly and positively influenced by education of the household head. The educated household head is better able to comprehend the necessity of marketing organisation like co-operatives for profitable farming and thus a positive association is envisaged in the study (Table 3). The findings of the study, consistent with Abate *et al.* (2014) and Mojo *et al.* (2017), shows positive and statistically significant relation between the variable 'beneficiary of government dairy development programme' and becoming member of DCS, indicating that beneficiary farmers have 50.67 per cent higher chance of becoming member of DCS. This may be because farmers could be easily reached for providing free green fodder seeds and subsidised concentrates as part of government dairy development programmes through a network of DCS. Farmers may be motivated to take membership if they find such programmes in place. Meeting the extension agents frequently may become an important source of information for farmers which may influence positively the membership of DCS. In our study too we found a positive and significant relation between membership of DCS and access to extension support. The remaining variables namely, age, family size, distance to all-weather road, access to credit and financial inclusion are according to the expected sign but found statistically insignificant. Variables such as herd size and price of milk are negatively associated with membership of DCS. This may have the implications that members are smaller size farmers with more high yielding crossbred cattle compared to their non-members. Similarly, although price of milk can be an important signal to motivate farmers to take membership of DCS, several studies point out that co-operatives are weak in offering better prices (Chagwiza *et al.*, 2016; Kumar *et al.*, 2013; Bardhan and Sharma, 2012). However, obvious indication is such that, the better-off farmers tend to join DCS as results are somewhat consistent with the descriptive statistics (explanatory variables) in Table 2.

TABLE 3. PROBIT ESTIMATION OF FACTORS INFLUENCING MEMBERSHIP OF DCS

Variables (1)	Coefficient (2)	Std. error (3)	Marginal effect (4)
Age	0.0085	0.0097	0.0030
Education	0.0661**	0.0270	0.0238
Family size	0.0401	0.0464	0.0145
Herd size	- 0.0152	0.0229	- 0.0055
Distance to all-weather road	0.0001	0.0003	0.0005
Access to credit	0.3104	0.3263	0.1164
Beneficiary of government dairy development programme	1.3717***	0.2904	0.5067
Extension	0.0575***	0.0143	0.0207
Financial inclusion	0.2191	0.2999	0.0768
Price of milk	- 0.0079	0.0103	- 0.0028
Constant	- 2.2259***	0.7324	
LR Chi^2 (8)	101.15		
Prob> Chi^2	0.000		
Pseudo R^2	0.3700		
Number of observation	202		

Source: Author's estimation based on field survey data

Notes: ** and *** Significant at 5 and 1 per cent level, respectively; marginal effects are estimated using 'mfx' command in STATA 14 after Probit model estimation.

Covariate Balancing Test Results

The second step of PSM is the matching of members and non-members of DCS (treatment and control) on their propensity scores using three different matching algorithms/estimators. Table 4 shows that the pseudo R^2 of the estimated Probit model indicating how well the relevant covariates explain the probability of becoming member of DCS, was high before matching (37 per cent) comes down to the range of 3.8 to 6.7 per cent. In similar lines, the *p*-values of the likelihood ratio test of the joint significance were all significant before matching becomes insignificant after matching. This points out that no systematic differences are seen in the distribution of covariates between members and non-members of DCS after matching. The joint significant impact of the observable covariates on DCS membership decision, expressed by significant χ^2, could not be rejected before matching was always rejected after matching for all the matching estimators. The mean absolute standardised bias are in the range of 11.1 to 15.6 per cent (all below 20 per cent as per the requirements) indicating a good match of the treated and control group.

Overlap or common support was also checked by visual inspection at the distributions of the propensity scores for the members and non-members of DCS (Figure 1). It shows that the two distributions are greatly overlapped. Propensity scores that lie outside the common support regions are shown on the graph as 'treated off support' indicating that they do not have suitable comparisons and are dropped in the treatment impact estimations.

TABLE 4. INDICATORS SATISFYING BALANCING PROPERTY BEFORE AND AFTER MATCHING

Matching algorithm (1)	Pseudo R^2 before matching (2)	Pseudo R^2 after matching (3)	LR χ^2 (p-value) before matching (4)	LR χ^2 (p-value) after matching (5)	Mean standardised bias before matching (6)	Mean standardised bias after matching (7)	Total per cent bias reduction (8)
NNM[a]	0.370	0.038	101.15*** (0.000)	6.68 (0.755)	45.2	11.1	75.44
KBM[b]	0.370	0.061	101.15*** (0.000)	10.90 (0.365)	45.2	15.6	65.48
RM[c]	0.370	0.067	101.15*** (0.000)	11.97 (0.287)	45.2	15.5	65.71

Source: Author's estimatiom based on field survey data.
Note: *** Significant at 1 per cent.
a NNM = five nearest neighbor matching with replacement and common support.
b KBM = kernel based matching with band width 0.06 and common support.
c RM = radius matching with caliper 0.1 and common support.

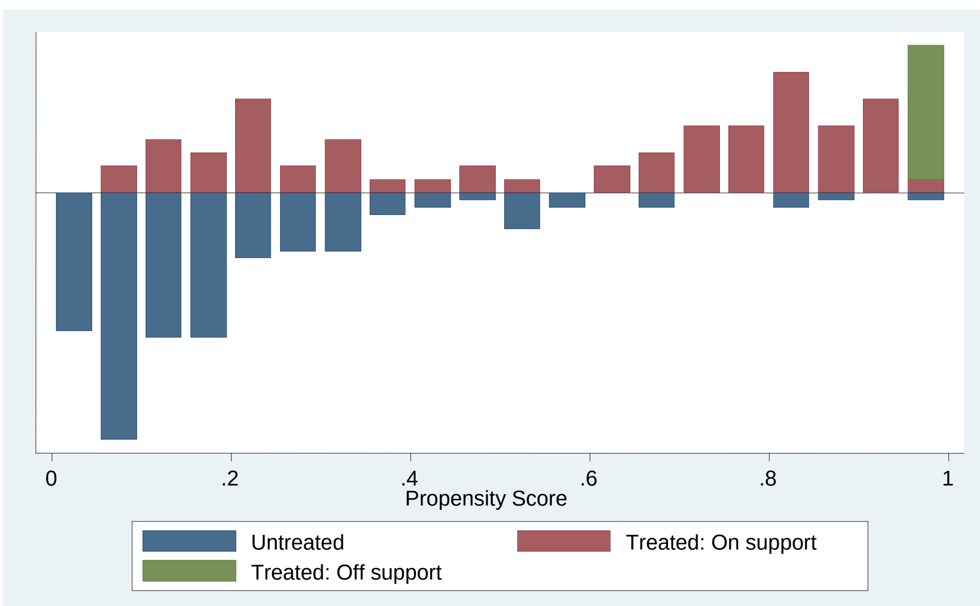

Figure 1. Distribution of the Propensity Scores and Common Support for Propensity Score Estimation for the DCS Members and Non-Members.

Impact of DCS Membership

To estimate the impact of being member of DCS, PSM method was employed to estimate the average treatment effect on the treated (ATT) after matching the member and non-member groups. For the sake of robustness of the results alternative estimators were used (Table 5). The results showed that all the estimators had almost similar results for their respective outcome variables. It is evident from Table 5 that taking membership of DCS seem to motivate farmers to adopt improved farm practices such as green fodder cultivation, adoption of AI and concentrate feeding per litre of milk which are important for raising overall dairy productivity. More specifically, rate of fodder cultivation will be less by a significant 49.37-51.25 (*p*-value=0.000) percentage points if the farmer is not a member of DCS. Similarly, there is a positive and statistically significant effect (*p*-value=0.000) of DCS membership on adoption of AI. Farm households with membership of DCS and doing AI for their animals are higher by 37.58 – 40.69 per cent compared to the counterfactual non-members. Finally, both members and non-members fed concentrate to their animal but with a significantly varying degree. Table 5 shows that members of DCS are found to feed more concentrate per litre of milk produced daily to the farm animals as compared to the non-members by the range of 209.41 to 228.17 grams/per litre of milk.

TABLE 5. ESTIMATION OF ATT: IMPACT OF DAIRY CO-OPERATIVE SOCIETY ON ADOPTION OF IMPROVED FARM PRACTICES

	NNM (5)	KBM (0.06)	RM (0.1)
Outcome variables		ATT	
(1)	(2)	(3)	(4)
Fodder cultivation	0.5125***	0.4937***	0.5034***
	(5.53)	(4.27)	(3.89)
Adoption of AI	0.4031***	0.3758***	0.4069***
	(3.41)	(3.47)	(3.57)
Concentrate feeding	228.1742***	213.7756***	209.4082***
	(2.98)	(2.63)	(3.28)

Source: Author's estimation based on field survey data.

Note: ATT estimates of all matching algorithms are obtained through implementation of 'psmatch2' command (given by Leuven and Sianesi, 2003) in STATA 14; Figures within brackets are the bootstrapped z statistics using 50 replications; ***Significant at 1 per cent.

NNM (5) = five nearest neighbour matching with replacement and common support.

KBM (0.06) = kernel based mathing with bandwidth 0.06 and common support.

RM (0.1) = radius matching with caliper 0.1 and common support.

IV

CONCLUSION

In the study an attempt was made to see the impact of dairy co-operative society on adoption of certain improved farm practices which can be considered production augmenting. Since, simple comparison between members and non-members of DCS is associated with selection bias due to non-randomness in the selection of being in the treatment group, propensity score matching technique was employed to arrive at unbiased estimates of the outcome variables.

The findings show a positive and statistically significant impact of smallholder dairy farmers' participation in dairy co-operative society on green fodder cultivation, adoption of AI, and feeding concentrate to the farm animal. The ATT estimates of three different matching algorithms show that the rate of fodder cultivation is significantly reduced by 49.37-51.25 per cent if the farmer is not a member of DCS. Similarly, rate of adoption of AI among members of DCS is significantly more over the counterfactual non-members by a range of 37.58-40.69 per cent. Finally, although both the DCS membership groups feed concentrate to their animal, members of DCS fed more concentrate in the range of 209.41-228.17 gram/litre of milk produced. These results have important implications for the dairy development in Assam. Facilitating dairy farmers' access to market through DCS or other such farmer producer organisation may enhance milk productivity and production of the state. Hence, there is a need towards distribution of green fodder seed and subsidised concentrate feed to the farmers through DCS under certain dairy development programmes. Furthermore, in AI diffusion programme of the state to raise high yielding crossbred cattle population, DCS has to be identified as an important medium for the knowledge dissemination on AI to increase its rate of adoption. Overall, given the positive impact of DCS participation, the system of co-operative dairying in the state needs to be strengthened to improve the overall scenario of the dairy sector.

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NOTES

1) The selection bias may arise because treatment (members of DCS) and control (non-members) groups may be systematically different on their observed and unobserved characteristics and members may self-select to be in the treatment group.

2) PSM is based on two main assumptions: one, conditional independence assumption (CIA) or unconfoundedness, that is after controlling for observed covariates (X_i) the potential outcomes of our interest are independent of treatment assignment; two, common support or overlap assumption indicating that after matching members and non-members lie in the same domain.

3) For more details on matching algorithms see Caliendo and Kopeinig (2008) and Becker and Ichino (2002).

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