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Impacts of dairy cooperatives in smallholder dairy production systems: a case study in Assam

Baban Bayan

Department of Humanities and Social Sciences,
Indian Institute of Technology Guwahati-781039, Assam, India

Abstract This paper assesses the impact of membership of dairy cooperative societies (DCS) on the performance of smallholder dairy production systems in Assam using matching techniques. Findings show that membership of DCS contributes towards improving yields of dairy animals, farm income and employment; and also, to household milk consumption. Nonetheless, it does not have a significant impact on technology adoption. The milk prices offered by dairy cooperatives are also less compared to the prices in wet market. These results indicate towards the need to improve dairy farmers linkages through cooperatives or other such instituions.

Keywords Dairy cooperative society, propensity score matching, impact, Assam

JEL classification Q12, Q13

1 Introduction

In developing countries, smallholder dairy farmers face several constraints related to production and marketing (Mojo et al. 2017). Producers' organizations such as dairy cooperatives can play an important role in alleviating these constraints (Staal et al. 1997; Chagwiza et al. 2016). According to Holloway et al. (1999) and Chagwiza et al. (2016), the cooperative, by bringing buyers and sellers together, can contribute towards reducing price risk and enhancing bargaining power of producers. Apart from this, cooperatives and other such producer organizations can foster skills of dairy producers, provide them appropriate information and knowledge and help innovate and adapt to the changing market conditions (FAO 2012).

In India, dairy cooperatives have been the vehicle for 'White Revolution'. The cooperative network expanded considerably after the launch of Operation Flood programme in 1970 (Kumar et al. 2013). However, the regional distribution of cooperatives has remained skewed; only four states, viz. Gujarat, Maharashtra, Karnataka and Tamil Nadu contribute about two-thirds to the total milk procurement, neglecting the states in eastern and north-eastern regions. The north-eastern state of Assam is one such state where, in spite of a higher cattle density, the per capita daily milk availability is quite low (78g). A few studies that have assessed the role of milk marketing system in Assam (Sirohi et al. 2009; Kumar et al. 2010; Kumar & Staal 2010) point towards institutional failure in linking farmers to markets. Efforts have been made through various programmes, such as *Rashtriya Krishi Vikash Yojana*, Assam Rural Infrastructure and Agricultural Services Project (ARIASP) and Assam Agricultural Competitiveness Project (AACP), to link dairy producers to markets through cooperatives. In 2015-16, there were 312 dairy cooperative societies in the state procuring about 8 million litres of milk from 16000 member-producers (NDDB 2016). This paper empirically assesses the impact of dairy cooperatives on several performance indicators of smallholder dairy production system of Assam, such as milk yield, technology adoption, farm income and household milk consumption.

*Corresponding author: babanbayan@gmail.com

2 Data and methodology

2.1 Data

The study is based on data collected from 202 dairy farmers in three districts of Assam during December, 2015 to March, 2016. A multistage sampling technique was followed for selecting the sample farmers. In the first stage, the districts were stratified in terms of high, medium and low concentration of dairy animals, and from each stratum one district was selected randomly. The districts so selected are Barpeta, Sonitpur and Karbi Anglong representing high, medium and low density respectively. In the second stage, two community development blocks were chosen from each district in such a way that one of these has higher concentration of dairy animals and the other has lesser concentration. The selection of the blocks was guided by inputs from key informants from the state department of animal husbandry and dairying. In the third stage, three villages, having a sizable dairy animal population, were purposively selected from each block. Finally, 30% of the total dairy farmers from each village were selected for implementation of the survey.

The sample households were categorized based on their membership status of dairy cooperative societies (DCS). For the purpose, we considered members of only the active DCS. Thus, the ultimate sample comprised of 202 dairy farmers, of which 75 were members and 127 were not.

2.2 Analytical approach

The empirical challenge in impact evaluation is to create a counterfactual (what would have been the impact in absence of farmers being member of dairy cooperatives) that can address the selection bias in observational studies (Kassie et al. 2011; Mojo et al. 2017; Rosenbaum & Rubin 1985). Rosenbaum & Rubin (1985), Heckman et al. (1997) and Caliendo & Kopeinig (2005) suggest that propensity score matching (PSM) based on conditional independence assumption (CIA) can address the problem of selection bias by conditioning on the observed characteristics by pairing each member household with one or more non-member households with similar observed characteristics. In essence, matching models simulate the conditions of an experiment where members and non-members are randomly assigned. Additionally, PSM is grounded on the assumption of overlap or common support that states that propensity scores of members and non-members remain in the same domain (a positive probability of becoming either member or non-member with same propensity score). Finally, PSM needs to fulfil the balancing property, i.e. covariate means of members and non-members should be the same after matching (Chagwiza et al. 2016; Mojo et al. 2017).

After satisfying these assumptions, we calculate the average treatment effect on the treated (ATT), i.e. the impact of DCS membership on dairy farm performance indicators of our interest. The ATT is computed as follows:

$$ATT = E(Y_1 - Y_0/C_i = 1) = E(Y_1/C_i = 1) - E(Y_0/C_i = 1) \quad \ldots(1)$$

Where, Y_1 and Y_0 are the performance indicators of smallholder dairy production system in the treated and untreated conditions, respectively; and C_i is an indicator variable denoting cooperative membership status.

First, we estimate conditional probability that a household would become member of DCS based on the observed characteristics using Probit model. The independent variables include age and education of the household-head, family size, herd size, ownership of crossbred cows, distance to market, access to institutional credit and experience in dairy farming. Table 1 provides definitions and measurements of these variables.

In the second step, matching algorithms are used to match treatment and control groups. The common matching algorithms, viz. nearest neighbour matching (NNM), Epanechnikov kernel based matching (KBM) with bandwidth 0.06 and radius matching (RM) with caliper 0.1 are used to estimate the ATT.

PSM requires fulfillment of the balancing property, i.e. to match the distribution of observed covariates to remove systematic differences in the distribution of covariates, and to ensure common support in the two groups after matching. Different covariate balancing tests are proposed in the literature. We have used two sample *t*-test (after matching there should not be any statistically significant difference) for comparing pseudo R^2 and *p*-values of the likelihood ratio test of the joint significance of all covariates obtained from

the Probit regression before and after matching. Sianesi (2004) suggests that the *p*-values of the likelihood ratio should be insignificant after matching. Whether the common support assumption is satisfied can also be visually inspected using the common support graph. Finally, Rosenbaum & Rubin (1985) suggest the use of mean absolute standardized bias (MASB) between members and non-members.

In this paper, we use the following specific outcome variables as indicators of dairy farm performance: (1) milk yield, (2) net dairy income, (3) proportion of dairy income in the total household income, (4) total labour use increase across all farm activities (as an indicator of employment generation); (5) proportion of milk sold as an indicator of intensity of market participation, (6) per capita daily milk consumption, and (7) proportion of calf born using AI (as an indicator of technology adoption). Their definitions and measurements are given in table 1.

3 Results and discussion

3.1 Descriptive Results

Table 2 presents the descriptive statistics. The members of dairy cooperatives significantly differ from non-members in the outcome indicators. They are systematically better off than non-members. However, results corresponding to the observed covariates indicate that members and non-members are to some extent similar with respect to age, family size, herd size and farm experience; but not in education, ownership of crossbred cattle, market distance and access to credit. For example, heads of member households are more educated than their non-member counterparts and also tend to adopt improved breeding technology.

Further, of the total farmer-members 28% have access to credit from formal sources as against 2.5% of the non-member farmers. Again, farmers residing nearer

Table 1. Definition and measurement of explanatory variables

Variable	Unit of measurement	Type of variable	Definition
Outcome variable			
Milk yield	Litre	Continuous	Milk production per day/milch animal
Net dairy income	Rupees	Continuous	Annual net dairy income of the household
Proportion of dairy income	Ratio	Continuous	Proportion of dairy income in total household income
Employment	Person days/month	Continuous	Total labour use
Price of milk	Rs.	Continuous	Price of milk per litre
Proportion of milk sold	Ratio	Continuous	Proportion of milk sold out
Per capita milk consumption	Gram	Continuous	Per capita daily consumption of self-produced milk
Proportion of calf born with AI	Ratio	Continuous	Proportion of calves born using AI
Explanatory variable			
Age	Years completed	Continuous	Age of household-head
Education	Years completed	Continuous	Years of schooling of household-head
Family size	Numbers	Continuous	Total household members
Herd size	Numbers	Continuous	Total number of cattle on the farm
Crossbred cattle	1 if crossbred cattle kept, 0 otherwise	Dummy	Ownership of crossbred cattle
Market distance	Kilometer	Continuous	Distance to nearest village market
Access to credit	1 if credit accessed, 0 otherwise	Dummy	Farmers accessed credit during last one year preceding the survey
Experience in dairy farming	Years completed	Continuous	Number of years since farm was started

Table 2. Descriptive statistics for outcome and explanatory variables

Variables	Treatment		Control		*Mean difference*
	Mean	Standard error	Mean	Standard error	
Milk yield	6.30	0.38	2.80	0.20	3.51***
Net dairy income	106549.90	18804.21	25147.23	2413.09	81402.66***
Proportion of dairy income	0.43	0.03	0.24	0.02	0.18***
Employment	29.91	2.09	15.44	0.91	14.47***
Price of milk					
Proportion of milk sold	0.77	0.02	0.64	0.02	0.13***
Per capita milk consumption	335.20	21.39	147.08	9.62	188.12***
Proportion of calf born with AI (*technological innovation*)	0.78	0.04	0.20	0.03	0.59***
Age	51.06	1.31	51.09	1.16	-0.03
Education	8.61	0.50	4.64	0.38	3.97***
Family size	5.82	0.32	6.11	0.22	-0.28
Herd size	6.16	0.65	6.20	0.38	-0.04
Crossbred cattle	0.84	0.04	0.24	0.04	0.59***
Market distance	2.62	0.14	3.42	0.16	-0.80***
Access to credit	0.28	0.05	0.09	0.02	0.19***
Farm experience	29.28	1.78	27.52	1.26	1.76

Source: Field survey.
*** indicates significant at 1% level.

to market are more inclined to be associated with dairy cooperatives.

3.2 Determinants of participation

Table 3 presents results of the Probit regression. The goodness-of-fit tests point out that selected observable covariates provide good estimates of the conditional DCS membership density. The joint statistical significance of the explanatory variables (LR Chi^2 test statistics) is 116.42 (p-0.000). The pseudo R^2 is reasonably good (0.4368) indicating a good fit of the model.

The probability of becoming member of a dairy cooperative society is significantly and positively influenced by education level of the household-head ($p<0.01$). The possible explanation is that education puts a person in a better position to comprehend likely benefits of being a member. Other variables that are positively and significantly associated with DCS membership include the ownership of crossbred cows ($p<0.10$) and access to institutional credit ($p<0.10$). Farm households with at least one crossbred cattle and having access to formal credit are more likely to join

Table 3. Probit estimation of determinants of cooperative membership

Variables	Coefficient	Standard error	Marginal effect[a]
Age	-0.01	0.01	-0.00
Education	0.11*	0.05	0.04
Family size	-0.01	0.05	-0.00
Herd size	-0.04*	0.02	-0.01
Crossbred cattle	1.78***	0.25	0.57
Market distance	-0.23***	0.08	-0.08
Access to credit	0.98***	0.33	0.37
Duration of the farm	0.01	0.01	0.00
Constant	-1.05	0.67	
LR Chi^2 (8)	116.42***		
Prob> Chi^2	0.000		
Pseudo R^2	0.4368		
Number of observation	202		

Source: Estimated by author. *, ** and *** indicate significant at 10%, 5% and 1% level respectively; [a]Marginal effects are estimated using 'mfx' command in STATA 14.

Table 4. Indicators of matching quality before and after matching

Matching algorithm	Pseudo R^2 before matching	Pseudo R^2 after matching	LR χ^2 (p-value) before matching	LR χ^2 (p-value) after matching	Mean standardized bias before matching	Mean standardized bias after matching	Total % bias reduction
NNM[a]	0.44	0.06	116.42 (p=0.000)***	10.47 (p=0.234)	53.9	17.8	66.98
KBM[b]	0.44	0.04	116.42 (p=0.000)***	7.18 (p=0.517)	53.9	15.4	71.43
RM[c]	0.44	0.04	116.42 (p=0.000)***	7.00 (p=0.537)	53.9	12.7	76.44

Source: Estimated by author; *** indicate significant at 1% level.
[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.

the cooperatives. Herd size has a negative and significant effect ($p<0.01$) on the likelihood of becoming DCS member, implying that membership decision may not be influenced by herd size. On the other hand, ownership of high yielding crossbred cows has a positive and significant association with cooperative membership. Distance to nearest market negatively affects the decision to participate in cooperatives. This indicates that farm households located nearer to the market have more cooperative participation rate, contradicting the understanding that nearness to market provides options to farmers to sell their produce to alternative channels.

3.3 Impact of participation in cooperatives

This section discusses the quality of the matching process. As observed by Lee (2008) and Becerril & Abdulai (2009), the propensity score only serves as an instrument to match the distribution of observable covariates across treated and control groups. The success of propensity score is, therefore, grounded in the resultant matching. Table 4 presents quality of the matching between the treatment and comparison groups. Conforming to the requirement of covariate balancing test, the Pseudo R^2 has come down significantly from 44% before matching to 4-6% after matching. The likelihood-ratio of the joint significance of all regressors before matching was high across the matching estimators indicating that there were systematic differences between the treatment and comparison groups. These differences have been removed after matching and the two groups became comparable (insignificant *p*-values after matching). Furthermore, matching process resulted in substantial reduction in bias (66.98-76.44%) after matching.

Finally, the visual inspection of the distributions of the propensity scores for DCS members and non-members after matching indicates that the groups are overlapped to a great extent (fig. 1). Suitable matches of DCS members and non-members are shown as 'treated on support' and 'untreated' respectively. DCS members with bad matches from among the non-members are referred on the graph as 'treated off support'

The estimates of the impact of dairy cooperatives, as average treatment effect on the treated (ATT), on selected farm performance indicators are presented in table 5. The ATT results for different matching algorithms, albeit, quantitatively different, qualitatively these are similar. Members of cooperatives are found to have significantly higher milk yield over the non-members. They, however, receive lower price compared to the prevalent open market price. Cooperatives provide a door-step market access, and inputs and services to their members and ensure a higher yield. These benefits, thus, compensate for the lower price. Further, cooperative members receive dividends at the end of the year. This is reflected in the higher annual net dairy income, higher employment and higher milk sales. Further, Kumar et al. (2013) observed that members of DCS owned significantly higher improved cattle breeds compared to the

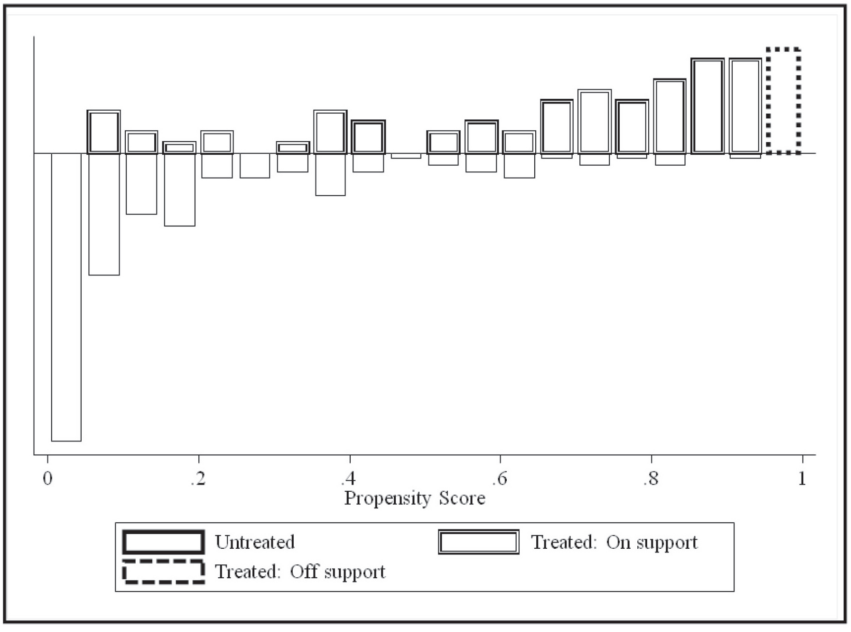

Figure 1. Distribution of the propensity scores and common support

Table 5. Estimation of ATT: Impact of dairy cooperatives society on farm performance

Outcome Variables	NNM (5)[d]	KBM (0.06)[e]	RM (0.1)[f]
		ATT[b]	
Milk yield	1.99 (3.09)[c]***	1.61 (2.05)**	1.80 (2.78)***
Net dairy income (Rs)[a]	70184.69 (2.97)***	67356.44 (2.95)***	68486.11 (2.98)***
Proportion of dairy income	0.09 (1.28)	0.09 (1.73)*	0.09 (1.78)*
Employment	14.61 (4.27)***	14.99 (4.80)***	14.37 (4.22)***
Price of milk	-4.90 (3.02)***	-4.26 (2.64)***	-4.50 (3.43)***
Proportion of milk sold (*intensity of market participation*)	0.13 (1.68)*	0.11 (1.62)	0.10 (1.30)
Per capita milk consumption	134.86 (3.10)***	96.39 (1.94)*	110.58 (2.55)**
Proportion of calf born with AI (*technological Innovation*)	0.03 (0.36)	0.04 (0.55)	0.05 (0.86)

Source: Estimated by auhor.
[a]Net dairy income is calculated as: gross value from the sale of milk and milk products plus imputed value of milk consumed within the household minus the paid out cost; [b]ATT estimates of all matching algorithms are obtained through implementation of 'psmatch2' command (Leuven & Sianesi, 2003) in STATA 14.
[c]Figures in parentheses are bootstrapped z statistics using 50 replications; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively.
[d]NNM (5) = five nearest neighbour matching with replacement and common support.
[e]KBM (0.06) = kernel based mathing with bandwidth 0.06 and common support.
[f]RM (0.1) = radius matching with caliper 0.1 and common support.

independent farmers leading to significantly higher market participation for members. It is interesting to note that members of dairy cooperative societies have significantly higher per capita household milk consumption compared to that by non-member households. This implies that commercialization of milk production does not adversely affect milk consumption.

These findings are consistent with findings of some earlier studies (Chagwiza et al. 2016; Kumar et al.

2013; Bardhan & Sharma 2012). However, unlike ours, these did not control for the confounding factors that may influence farmers' self-selection.

4 Conclusions and policy implications

In this paper we have assessed the impact of dairy cooperatives on some selected farm performance indicators of smallholder dairy production system in Assam. Given the non-experimental nature of data, propensity score matching technique was employed to address the selection bias. The results indicate presence of bias in the distribution of covariates between groups of treatment and comparison suggesting that accounting for self-selection bias is necessary to obtain unbiased estimates of outcome indicators.

The findings show a positive and statistically signficant impact of farmers' participation in dairy cooperatives on milk yield, farm income, marketed surplus and employment and without having any advese effect on household milk consumption. The prices offered by cooperative, however, are less than the open market prices.

These results have some important implications for dairy development in Assam. Enhancing farmers' access to market through DCS or other such instituions can stimulate milk production in the state. Hence, there is a need to attract cooperative or private investment in dairying by creating a level playing field for different stakeholders. Two, the cooperatives have to think of milk price policy keeping into consideration the open market prices. Three, there is a need to disseminate improved technologies to farmers.

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