Economic Impact of Cooperative Membership on Women Dairy Farmers: Evidence from the Mulkanoor Women Dairy Cooperative, Telangana, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Aims: To identify the determinants of cooperative membership among women dairy farmers in the Mulkanoor Women Dairy Cooperative and to assess its impact on milk yield, price received, production cost, and net returns.

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Study Design: Cross-sectional primary survey combined with econometric impact evaluation using Propensity Score Matching (PSM).

Place and Duration of Study: The study was conducted in the three districts of Telangana - Hanumakonda, Karimnagar and Siddipet where the Mulkanoor Women Dairy Cooperative is active. Data collection was carried out from April to July 2025.

Methodology: The study sample consisted of 180 women dairy farmers—90 cooperative members and 90 non-members—selected through multistage random sampling from 18 villages in three districts, with 60 respondents drawn from each district. Data on socio-economic characteristics, milk productivity, prices, and costs were obtained via structured interviews. A binary logistic regression model was used to identify factors influencing cooperative membership. To estimate the economic impact of membership, Propensity Score Matching (nearest neighbour, kernel, and caliper methods) was applied to control for selection bias. Matching quality was evaluated using balance diagnostics such as standardized mean bias, t-tests, pseudo-R^2, and joint significance tests. Outcome variables included net cost per litre, net income per litre, milk yield (L/animal/day), and price received (Rs/L).

Results: Logistic regression results showed that age (with a non-linear effect), dairy experience, landholding size, proximity to collection centres, and herd size significantly influenced membership, while education and household size did not. Propensity Score Matching analysis confirmed strong covariate balance and highlighted significant economic advantages for cooperative members. The net cost of milk production was considerably lower for members (Rs. 17.75/litre) compared to non-members (Rs. 31.39/litre), reflecting cost savings of Rs. 14–17 per litre. Although the base price received by members was about Rs. 15/litre lower than prevailing market rates, bonus incentives (Rs. 14 per Rs. 100 worth of milk sold) combined with reduced production costs (Rs. 12–15/litre less) enhanced their net returns by approximately Rs. 6/litre. Moreover, members demonstrated significantly higher productivity, producing about 6 litres more milk per animal per day than non-members, a difference confirmed to be statistically significant by the Average Treatment Effect on the Treated (ATT) estimates.

Conclusion: Membership in the Mulkanoor Women Dairy Cooperative has a significant positive economic impact by enhancing milk productivity, lowering production costs, and increasing net returns for women dairy farmers. These findings underscore women-led cooperatives as effective mechanisms for driving inclusive and sustainable rural economic growth. Key policy implications include the need to support women-led cooperatives through targeted credit facilities, improved infrastructure, capacity-building programs, and integration into broader dairy value chains to amplify productivity and income stability.

1. INTRODUCTION

Dairy production holds a vital place in India's agricultural sector, serving as a key source of livelihood for millions of rural households and contributing significantly to the viability and sustainability of farming systems across the country. India emerged as the world's largest milk-producing country, contributing 239.3 million tonnes of milk in 2023-24, accounting for around 25 per cent of global milk production (Indiastat, 2024). However, despite its leading position in total milk production, the average milk yield per animal remains low compared to global standards. The annual growth rate of milk production has decreased from 5.77 per cent to 3.78 per cent during 2021-22 to 2023-24 (Animal Husbandry Statistics, 2023-2024), indicating emerging productivity and growth challenges.

This situation underscores the persistent challenges of improving productivity in a fragmented sector characterized by millions of small-scale dairy farmers dispersed over diverse geographic regions. The rapidly growing population and rising income levels have escalated demand for milk and dairy products, intensifying pressure on the dairy sector to enhance production efficiency and supply chain coordination. However, smallholder dairy farms' scattered nature hinders market access, technology adoption, and resource pooling, limiting collective growth and productivity gains (Kebebe, 2015).

Dairy cooperatives in India have played a critical role in addressing these structural challenges by organizing farmers into collective groups that enable economies of scale, improved market

integration, assured procurement, and better access to technical, financial, and input supply services (Gaillard & Dervillé, 2022; Mahida et al., 2018). Membership in cooperatives has expanded substantially from 8.99 million in 1994-95 to 15.65 million members in 2023, reflecting a 74 per cent growth and highlighting their growing socio-economic importance (Indiastat, 2023).

Women have historically been central to daily livestock management tasks such as feeding, milking, and animal healthcare but have often been undervalued and excluded from economic benefits and decision-making (Farnworth et al., 2023). Furthermore, recent studies from Karnataka and Andhra Pradesh highlight persistent constraints faced by women members of dairy cooperatives, including limited access to resources and challenges in decision-making regarding farm activities (Suresh N. Sajjan et al., 2024; Keerthi et al., 2023). Globally, collective action through women-led organizations has been shown to improve market access and empower rural women economically and socially (Hellin, et al., 2009; Meinzen-Dick et al., 2011). Recognizing this, women-led dairy cooperatives have emerged to enhance women's income generation, improve milk productivity, and promote rural gender equity (Dash et al., 2020); (Sarker, 2023). Among these, the Mulkanoor Women Dairy Cooperative in Telangana is a pioneering example, established in 2002 in Mulkanoor village in Hanumkonda district of Telegana. It has grown from 200 members across 14 villages to over 23,000 members in 192 villages, providing assured milk procurement, fair prices, technical support, and capacity-building training that have empowered women farmers economically and socially (McMurtry & McMurtry, 2015).

While past studies have documented the socio-economic empowerment and gender inclusion impacts of women dairy cooperatives (Farnworth et al., 2023; Dash et al., (2020) Sarker, 2023), there remains a critical need for evidence on the economic impacts of cooperative membership on milk yield, cost efficiency, and returns specifically among women farmers in the Mulkanoor cooperative context. This study addresses this gap by examining determinants of cooperative membership and assessing how membership affects milk productivity, costs, and economic returns for women dairy farmers.

The general objective of this research is to evaluate the economic impact of cooperative membership on women dairy farmers in the Mulkanoor cooperative. The specific objectives are:

1. To identify the determinants of cooperative membership among women dairy farmers in Mulkanoor.

2. To assess the impact of cooperative membership on milk yield, price received, cost and return.

2. MATERIALS AND METHODS

2.1 Data

Primary data were collected in 2025 from three randomly selected districts of Telangana where the Mulkanoor Women Dairy Cooperative operates. Using a multistage random sampling method, two mandals were chosen per district and three villages per mandal, giving 18 villages. In each village, five cooperative members and five non-members were randomly selected, totaling 90 members and 90 non-members altogether to a sample size of 180 respondents. Since the cooperative is restricted to women-only, the non-member sample consisted of major women dairy households from the same area to ensure comparability.

2.2 Analytical Framework

A binary logistic regression model was used to examine the relationship between cooperative membership status (D) and household characteristics. Membership was coded as D=1 for members and D=0 for non-members. To estimate the impact of cooperative membership on the outcome variables, we applied a Propensity Scores Matching (PSM) technique, in order to control for biases that may exist between the two groups (members and non-members).

The primary challenge in evaluating the impact of cooperative membership is constructing a valid counterfactual—that is, estimating the outcomes that members would have experienced had they not participated in the cooperative, denoted as $E(Y^0|D=1)$. Since this counterfactual is inherently unobservable, statistical techniques like PSM are necessary to identify appropriate comparison groups.

For estimating propensity scores logistic model was used as a function of selected independent variables. The dependent variable, membership

status D, was coded as 1 for members and 0 for non-members. The choice of independent variables is crucial for the model. According to Caliendo & Kopeinig, (2008) only variables that influence simultaneously the participation decision and the outcome variable should be included. Selected covariates should either be fixed over time or measured before participation to avoid endogeneity. Following their suggestion and reviewing literatures the variables selected are age of the women dairy farmer, (age of the women dairy farmer)[2], dairying experience, total landholding, distance to the nearest milk collection center, and herd size. In the current study, the outcome variables used are (1) Net cost per litre of milk (2) Net income per litre of milk (3) Milk yield (L/animal/day) (4) Price recieved (Rs/litre). The propensity score—the conditional probability of membership given observed covariates—was thus estimated as given in equation 1:

$$P(X_i) = Pr(D_i = 1 \mid X_i) = \frac{e^{\beta_0 + \Sigma_{j=1}^{k} \beta_j X_{ij}}}{1 + e^{\beta_0 + \Sigma_{j=1}^{k} \beta_j X_{ij}}} \quad (eq.1)$$

where X_i represents the vector of covariates for household i.

Given the indicators, we aim to calculate the average treatment effect on the treated (ATT) as given in equation 2:

$$ATT = E(Y^1 \mid D = 1) - E(Y^0 \mid D = 0) \quad (eq.2)$$

where: Y^1 performance in treatment group

Y^0 = performance in control group

To estimate ATT, this counterfactual outcome is approximated by the observed outcomes of a matched group of non-members (control individuals) with similar propensity scores, under the assumption that these non-members represent a valid comparison group.

Several matching algorithms are available for PSM. In this study we employ three methods: (1) nearest neighbour matching 'with replacement' (2) Kernel matching and (3) Caliper matching. In nearest neighbour method, the individual from the comparison group is chosen as a matching partner for a treated individual that is closest in terms of the propensity score. Matching with replacement was allowed to improve match quality and reduce bias (Smith & Todd, 2001).To avoid the risk of bad matches arising from nearest neighbor, common support conditions are imposed known as caliper (propensity range). Caliper matching increases the matching quality however there is a risk of increase in variance of estimates. Kernel matching is a non-parametric approach in which each treated unit was matched to a weighted average of all control units, with weights inversely proportional to the distance in propensity scores. This method reduces variance by using more information but risks including poorer quality matches.

Observations outside the region of common support were excluded to ensure valid comparisons. Matching quality was evaluated using multiple balance diagnostics such as two-sample t-tests for equality of covariate means, joint significance tests of all regressors, pseudo-R^2 before and after matching and standardized mean bias for each covariate.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

Descriptive statistics of the sample are presented in Table1. The results indicate a statistically significant age difference of about three years between members and non-members, with non-members being older on average. Members have, on average, one year more of formal education than non-members, and this difference is significant at the 5% level. Household size is comparable between the two groups. The dairying experience of women members is, on average, two years greater than that of non-members, a difference that is highly significant. Members own, on average, 0.58 acres more land than non-members, significant at the 5% level. In terms of location, members are situated closer to milk collection centres, at an average distance of about 700 metres, compared to 1.35 kilometres for non-members. Members also own, on average, two more cattle than non-members, with this difference being highly significant. Regarding caste composition, around 26% of sampled members belong to the General category, implying that 74% belong to marginalized categories such as SC, ST, and OBC; however, the caste distribution difference between members and non-members is not statistically significant. Along with the original variables, the squared terms for age and education were included in the descriptive statistics to capture potential non-linear relationships between these covariates and the probability of cooperative membership.

Table 1. Descriptive statistics of overall sample

Variables	Members		Non-members		
	Mean	SD	Mean	SD	Mean Difference
Age (years)	44.62	8.68	47.71	11.11	3.09**
Education (years)	3.13	3.78	2.11	3.03	-1.02**
Total members in HH	4.65	1.26	4.68	2.36	0.03[ns]
Dairy experience (in years)	12.96	6.14	10.76	5.07	-2.20***
Landholding (acres)	3.19	1.93	2.61	1.78	-0.58**
Distance to the nearest milk collection centre (kms)	0.73	0.89	1.35	0.8	0.61***
Herd size (numbers)	5.42	4.14	2.87	1.91	-2.55***
Caste: 1 if household belongs to non-marginalised category, 0 otherwise	0.26	0.44	0.17	0.37	-0.09[ns]
Age squared	2,065.62	790.66	2,398.49	1,069.81	332.87**
ln(landholding)	1.06	0.57	0.86	0.61	-0.20**
Education squared	23.96	38.8	13.53	27.98	-10.42**

*Source: Estimated by author. *, ** and *** indicate significant at 10%, 5% and 1% level respectively*

3.2 Determinants of Participation in Mulakanur Women Dairy Cooperative Society

Table 2 presents the results of the binary logistic regression model estimating the probability of dairy cooperative membership as a function of household characteristics. The model exhibits a good overall fit, with a likelihood ratio chi-square of 89.33 (p = 0.000), and a pseudo R^2 of 0.358, suggesting that the selected covariates explain a substantial proportion of the variation in membership status. Among the covariates, age has a statistically significant positive effect ($p < 0.05$) on cooperative membership, indicating that as the respondent's age increases, the likelihood of being a member rises. However, the negative and significant coefficient for age squared ($p < 0.05$) suggests a non-linear, inverted-U shaped relationship: the probability of membership increases with age up to a certain point and then declines, implying middle-aged farmers are most likely to participate. Dairy farming experience was also found to be positively and significantly associated with membership ($p < 0.01$), reflecting that households with more years of experience in dairy farming are more inclined to join cooperatives. This may be due to greater awareness about the potential benefits and functioning of cooperatives among experienced farmers. In contrast, total landholding has a positive and significant effect ($p < 0.05$), indicating that households with larger landholdings are more likely to be members. This could be attributed to larger landholders having more resources to invest in dairy activities and being more engaged in formal producer organizations. The distance to milk collection centre exhibits a negative and highly significant association ($p < 0.01$) with cooperative membership, suggesting that households located farther from milk collection centers are less likely to participate. Physical proximity likely reduces transaction costs and encourages participation. Herd size shows a positive and significant effect ($p < 0.01$), meaning that households with more dairy animals are more likely to become members. This is consistent with the idea that larger producers find it more beneficial to be linked with cooperative societies for regular milk marketing. On the other hand, neither education level nor household size were found to have statistically significant effects on membership status, suggesting that these factors may not be central in shaping the decision to join a cooperative in this context.

3.3 Impact of dairy cooperatives

This section evaluates the effectiveness of the matching process, drawing on established standards for propensity score matching diagnostics. As indicated by Lee, (2013) and Becerril & Abdulai, (2010), the primary function of the propensity score is to facilitate the alignment of observable covariate distributions between treated and control groups, and the credibility of the analysis depends on the quality of this resultant matching.

Table 2. Binary logistic regression model estimates for the probability of cooperative membership

Membership	Coef.	P > |z|	Margin effects[a]
Age	0.356	0.047 **	0.052
Age²	−0.005	0.018 **	-0.001
Education	0.068	0.293	0.009
Dairy farming experience (years)	0.170	0.000 ***	-0.024
Household size	−0.041	0.681	-0.005
Total landholding (acres)	0.235	0.039 **	-0.034
Distance to milk collection center	−1.200	0.000 ***	-0.173
Herd size	0.411	0.000 ***	0.059
Constant	−9.273	0.029 **	
Number of observations	180		
LR chi²	89.33		
Prob>Chi²	0.000		
Psuedo R²	0.358		

*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 3. Balancing test results of the model

		After matching		
Test	Before Matching	Nearest Neighbour	Kernel	Caliper
Pseudo R²	0.341	0.040	0.042	0.054
LR² (p value)	85.13(0.000)	6.04 (0.419)	6.36 (0.384)	7.514 (0.308)
Mean standardized bias (%)	47.9	13.6	11.2	16.1
Total bias reduction (%)	-	66.14	65.6	62.3

$***p < 0.01, **p < 0.05, *p < 0.10$

Table 4. Impact of dairy cooperative society on dairy farmers

Outcome Variable	Members (Mean)	Non-Members (Mean)	t-test (p value)	ATT[a]		
				NN(2)[c]	Kernel	Caliper(0.03)[d]
Net Cost per Liter of Milk (Rs)	17.75	31.39	-8.38(0.00)***	-15.01 (3.55)***	-14.41 (2.79)***	-17.62 (4.72)***
Net income per Liter of Milk (Rs/L)	36.59	35.01	0.65(0.41)ns	5.85(3.81)**	6.85(3.2)**	6.95(4.45)*
Milk Yield (L/animal/day)	16.45	8.34	7.46(0.00)***	6.55(1.71)***	6.32(1.91)***	6.35(2.45)***
Price received (Rs/L)	48.26	66.62	-9.85(0.00)***	-15.68 (3.51)***	-14.08(3.21)***	-17.22(3.94)***

*Source: Estimated by author. ; [a]ATT estimates of all matching algorithms are obtained through implementation of 'psmatch2' command (Leuven & Sianesi, 2003) in STATA 14; [b]Figures in parentheses are bootstrapped std error using 50 replications; *, ** and *** indicate significant at 10%, 5% and 1% level, respectively; ns=non significant; [c]NNM (2) = Two nearest neighbour matching with replacement and common support; [d]Caliper (0.03) = radius matching with caliper 0.03 and common support.*

Table 3 details several key balancing statistics before and after matching through nearest neighbour, kernel, and caliper algorithms. After matching, the Pseudo R² fell dramatically from 34.1% prior to matching to between 4.0% and 5.4% across all post-matching estimators, indicating a substantial improvement in balance between the treatment and comparison groups. Similarly, the LR chi² statistic dropped from 85.13 (p=0.000) before matching to much lower values (6.04–7.51) with non-significant p-values (0.308–0.419) after matching, demonstrating that systematic differences between groups were removed and that the matched groups are now statistically comparable. The mean standardized bias also followed this trend, decreasing from 47.9% before matching to 11.2–16.1% after matching, reflecting a notable reduction in covariate imbalance. Importantly, the total bias reduction following matching ranged from 62.3% to 66.14% (nearest neighbour: 66.14%; kernel: 65.6%; caliper: 62.3%), conforming to accepted thresholds in the literature which consider standardized mean differences below 10–20% and bias reductions above 50% to represent adequately balanced samples after matching Austin, (2009).

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 4.

The results consistently show that cooperative members enjoy substantially higher milk yields than non-members across all estimators. Specifically, ATT values of milk yield indicate that membership raises productivity by more than 6 litres per animal per day on average—a statistically and practically significant improvement. This productivity gain likely stems from enhanced access to superior feed, veterinary care, and technical support provided through the cooperative structure.

Despite this distinct productivity advantage, cooperative members receive a lower milk price compared to the prevailing open market rate, with a notable difference of approximately Rs. 15 per litre. However, this price differential is largely counterbalanced by the bonus system offered by the Mulkanur Women Cooperative Dairy (MWCD), which provides members with a bonus of Rs. 14 for every Rs. 100 worth of milk sold. These bonus payments, typically disbursed during festival seasons, offer members an additional, more stable source of income.

Together with the bonus, the lower price is further offset by reduced production costs and access to supplementary services and subsidies facilitated by the cooperative, which collectively contribute to members' economic resilience. Cooperative members also incur a significantly lower net cost of milk production compared to matched non-members, with ATT estimates indicating reductions of about Rs. 12 to 15 per litre across all matching methods. These cost savings are both statistically and economically significant, reflecting the cooperative's role in providing inputs, collective procurement, and other cost-reducing services. Regarding net income per litre, ATT estimates suggest a small positive effect of cooperative membership, but these differences are statistically significant at 5% and 10% significance level. This implies that, after controlling for observable characteristics, members' net income per litre is around Rs.6 more than that of non-members. Importantly, the major benefits of cooperative membership are realized not solely through improvements in price per unit sold, but through increased scale of operations, enhanced productivity, and risk-sharing mechanisms such as the bonus system and stable input supply. These factors collectively strengthen the economic position of cooperative members, underscoring the broader advantages of collective action in dairy production. Kumar et al., (2018) found that cooperative membership significantly improves dairy income, driven largely by higher milk yields and access to cooperative services. This aligns with findings by Chagwiza et al., (2016) who reported that member households achieve higher milk production compared to non-members, highlighting increased productivity as a key benefit of cooperative engagement. Regarding price, Bayan, (2018) and Priscilla & Chauhan, (2019) observed that cooperatives often pay members a lower milk price than the open market and higher milk yield.

4. LIMITATIONS AND SCOPE

While the study employed rigorous econometric techniques and multiple matching algorithms to minimize selection bias, certain limitations remain. Propensity Score Matching controls for observed characteristics, but unobserved factors such as management skills, household risk preferences, or social capital may also influence both cooperative membership and outcomes, potentially leading to residual bias in the estimated impacts. Additionally, the study is constrained by its relatively small sample size

(180 respondents) and geographic restriction which may limit the statistical power for detecting smaller effects and the generalizability of findings to other regions with varying institutional, socio-economic, or agro-ecological conditions. Despite these limitations, the results provide strong evidence of the economic, benefits of women-led dairy cooperatives, offering valuable lessons for policy and replication in similar contexts.

5. CONCLUSION

This study sought to fill the existing evidence gap on the economic impacts of a women-led dairy cooperative within the Mulkanoor context. The analysis demonstrates that membership in the Mulkanoor Women Dairy Cooperative is influenced by specific factors, including age (with a non-linear effect), dairy farming experience, landholding size, herd size, and proximity to milk collection centres, whereas education level and household size do not significantly determine participation. After controlling for selection bias through propensity score matching, the findings provide robust evidence that membership yields substantial economic gains for women dairy farmers. On average, members achieve milk yields exceeding those of comparable non-members by more than 6 litres per animal per day, primarily due to improved access to quality inputs, reliable veterinary services, and targeted technical support. Although cooperative members receive a base price for milk that is marginally lower than prevailing open market rates, this is compensated by bonus payments, reduced production costs, and secure access to inputs. These factors combine to enhance net returns by approximately Rs. 6 per litre, while improving cost efficiency and mitigating market-related risks.

From a broader perspective, the results reaffirm the pivotal role of women-led cooperatives such as Mulkanoor in overcoming structural constraints inherent in smallholder dairy systems—particularly in drought-prone rural areas. By improving productivity, stabilizing household incomes, and strengthening women's decision-making power, such cooperatives contribute directly to inclusive rural economic growth.

The empirical evidence highlights several actionable lessons for policymakers and rural development agencies. First, targeted support for women-led cooperatives—through concessional credit, infrastructure investment, and livestock development programs—can amplify productivity gains and income stability. Second, scaling the cooperative model to other dairy-growing regions should prioritize building accessible milk collection infrastructure, improving extension services, and enhancing women's participation in governance structures. Third, integrating cooperative networks into national dairy value chains can enhance market access while safeguarding producers against price volatility.

While the evidence is internally consistent and robust, the external validity of the findings is limited by the study's geographic focus and the unique institutional setting of a women-led cooperative. Nevertheless, the results provide valuable insights for similar rural contexts where collective action can enhance women's empowerment and economic viability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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