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**Research Article**

# Economic impact of dairy cooperative membership in Machakel District, North Western Ethiopia

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**Abstract:** *The emergence of agricultural cooperatives is widely seen as a crucial institutional structure that can help smallholder farmers in developing countries overcome the limitations that prevent them from fully benefiting from opportunities in agricultural production and marketing. However, there are limited studies in measuring the economic contribution of dairy cooperatives for member households. Thus, this study was done to examine the economic impact of dairy cooperative membership in Machakel District. A multi-stage sampling technique was used to select the sample households. Data were collected from 266 randomly selected households through an interview schedule. In addition, 4 focus group discussions and 10 key informant interviews were held to collect primary data. An endogenous switching regression model was applied to estimate the treatment effect by controlling selection bias and unobserved factors. The finding indicates, being a member of dairy cooperative increases household income by over 9% milk production by almost 70%, and milk productivity by over 21 percent. The study concluded that dairy cooperatives can be efficient in fostering the economic welfare of farmers with relatively higher income, milk production and milk productivity. Therefore, stakeholders should support dairy cooperatives to make them more attractive and sustainable for farmers.*

**Keywords:** Endogenous Switching Regression Model; Household Income; Milk Production; Milk Productivity
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## 1. Introduction

The livestock sector, especially the dairy and dairy products subsector, makes a substantial contribution to smallholder farmers in Ethiopia. It contributes to 45 percent of the agricultural GDP and 19 percent of the overall GDP (Statista, 2023); provides employment to over 30 percent of the agricultural labor force and 16 to 19 percent of export earnings of the country is generated from this sector (PSI, 2023). Ethiopia has a substantial livestock population, including over 71 million cattle, 43 million sheep, and 54 million goats (PSI, 2023). This large animal population gives the country significant potential for developing its dairy industry and plays a crucial role in reducing poverty and ensuring adequate nutrition among smallholder farmers in Ethiopia.

The country produces over 3.8 billion liters of milk valued at USD 5.1 billion per annum (CSA, 2019). However, the contribution of the livestock sector in

general, and the dairy sector in particular, falls below its capacity (Gebremedhin et al., 2007). Overall, Ethiopia's dairy industry performs poorly, even when compared to neighboring East African countries (Begny, 2023). Productivity in the traditional system was 1.48 L per cow per day in 2021 (CSA, 2021). The annual average milk yield for Ethiopia is 84 percent, 32 percent, and 12 percent behind the world, Africa, and East Africa, respectively (FAO, 2022). This production and productivity problem is associated with inadequate government service, insufficient infrastructure, and low adoption of improved technologies (Legesse et al., 2023). On the other hand, the government plans to increase milk production fourfold by 2031.

Thus, dairy cooperatives have been established to address these constraints and enhance the bargaining power of producers while reducing price risks, leading to achieving government targets (Chagwiza et al., 2016). Dairy cooperatives are widely regarded as a crucial institutional structure that can help smallholder farmers overcome the constraints and improve their livelihoods (World Bank, 2006). Dairy cooperative organizations have also been regarded as a valid growth and welfare improvement strategy in Ethiopia where the livelihood is dependent on agriculture (Bernard and Spielman, 2009; Markelova and Mwangi, 2010; Tomaquin, 2014). Based on the report of FCA (2016) cited by Daniel Belay (2018), there are only 504 dairy cooperatives engaged in milk production and marketing activities in different parts of the country. Based on the annual report of Amhara Region Cooperative Agency (2019), there are 3,145 active agricultural cooperatives in the region having a member of 3,088,509 people, of which only 126 are dairy cooperatives.

Moreover, dairy cooperatives have the potential to contribute significantly to poverty reduction and improve the livelihoods of smallholder farmers who are members of these cooperatives (Wanyama et al., 2008; Getnet and Anullo, 2012; Ito et al., 2012; Verhofstadt and Maertens, 2014; Leistritz, 2016). Studies have confirmed that dairy cooperatives have: brought a higher income (Fischer and Qaim, 2012); increased milk production and productivity (Ahmed et al., 2004; D'Haese et al., 2007; Francesconi and Ruben, 2012); and improved technical efficiency (Abate et al., 2014). Indeed, previous studies have presented inconsistent findings and varying levels of success concerning the performance and benefits of agricultural cooperatives. Some studies have shown that collective actions did not lead to improved situations for farmers (Poulton et al., 2010); such as, Cooperative membership brought a negative impact on productive asset accumulation (Getnet and Anullo, 2012); cooperatives were not successful in the commercialization of agricultural products (Bernard et al., 2008); dairy cooperatives didn't have a significant impact on the price of milk and butter (Chagwiza et al., 2016); approximately 40 percent of the members did not participate in collective marketing and instead sold their bananas separately (Fischer and Qaim, 2012). Given the evidence mentioned above, it is challenging to make a generalized conclusion that cooperatives universally benefit all members in all locations.

Moreover, most prior studies have examined the agricultural cooperative impacts on household welfare (Francesconi and Heerink, 2011; Getnet and Anullo, 2012; Abebaw and Haile, 2013; Mojo et al., 2015; Chagwiza et al., 2016; Ahmed and Mesfin, 2017; Mammo et al., 2021) in Ethiopia, (Nurudeen Afolabi and Olumuyiwa Ganiyu, 2021) in Nigeria, (Olumeh and Mithöfer, 2024) in Malawi, (Vuong et al., 2021) in Vietnam. However, except for Chagwiza et al. (2016), most of these empirical studies focus on agricultural cooperatives beyond dairy cooperatives. Chagwiza et al. (2016) analyzed the impact of dairy cooperatives on the performance of dairy producers using impact indicators, but the study was conducted in central parts of Ethiopia, Oromia region particularly in Selale. As a result, there is a limitation of empirical evidence on the economic impact of dairy cooperatives in the Amhara region. Moreover, these studies measure the impact of cooperatives using the propensity score matching (PSM) approach to take into account the selection bias. However, PSM estimates may be biased since this method does not take into account unobservable factors (Ma and Abdulai, 2016). The household decision to be a member of dairy cooperatives is voluntary and based on self-selection. Thus, in addition to observed characteristics, the unobserved characteristics of households such as farming ability, perception, attitude, and risk preferences affect their membership

decision and their outcomes (Di Falco et al., 2011). To mitigate these problems this study employs the endogenous switching regression model (ESR). Therefore, it is reasonable to conduct further analysis and generate more evidence regarding the economic impact of dairy cooperative membership specifically in north western Ethiopia, Amhara Region.

## 2. Methodology

### 2.1. Description of the study area

The study was carried out in the Machakel District, located in East Gojjam Zone of Amhara Region. The district has a total of 145,219 populations, which shows an increase of 22.97% over the 2007 census, of whom 72,007 are men and 73,203 are women; 16,332 or 11.25% are urban inhabitants and the remaining 128,888 or 89.75% are living in rural areas with an area of 746.43 $m^2$. A total of 20,202 rural households are counted in this district (MWAO, 2020).

Agriculture is the primary economic activity in the district, and its environmental conditions are well-suited for diverse agricultural pursuits. The local population relies heavily on both crop farming and livestock rearing as their main sources of livelihood and sustenance. Livestock production is a crucial component of the overall agricultural system in the district, encompassing a variety of animals like cattle, sheep, goats, horses, donkeys, mules, poultry, and honey bees. While market-oriented agricultural production is limited, smallholder dairy farming is rapidly growing in the district, with a strong emphasis on milk production and cooperative-based marketing channels (MWADO, 2020).

According to the district cooperative office report, there are 57 farmers' primary cooperatives in the district organized under nine types of cooperatives. Among these, there are 15 multipurpose cooperatives with 27,457 members and 29 saving and credit cooperatives with 2,922 members. Moreover, in the district, there are only 5 dairy production and marketing cooperatives having 610 members.

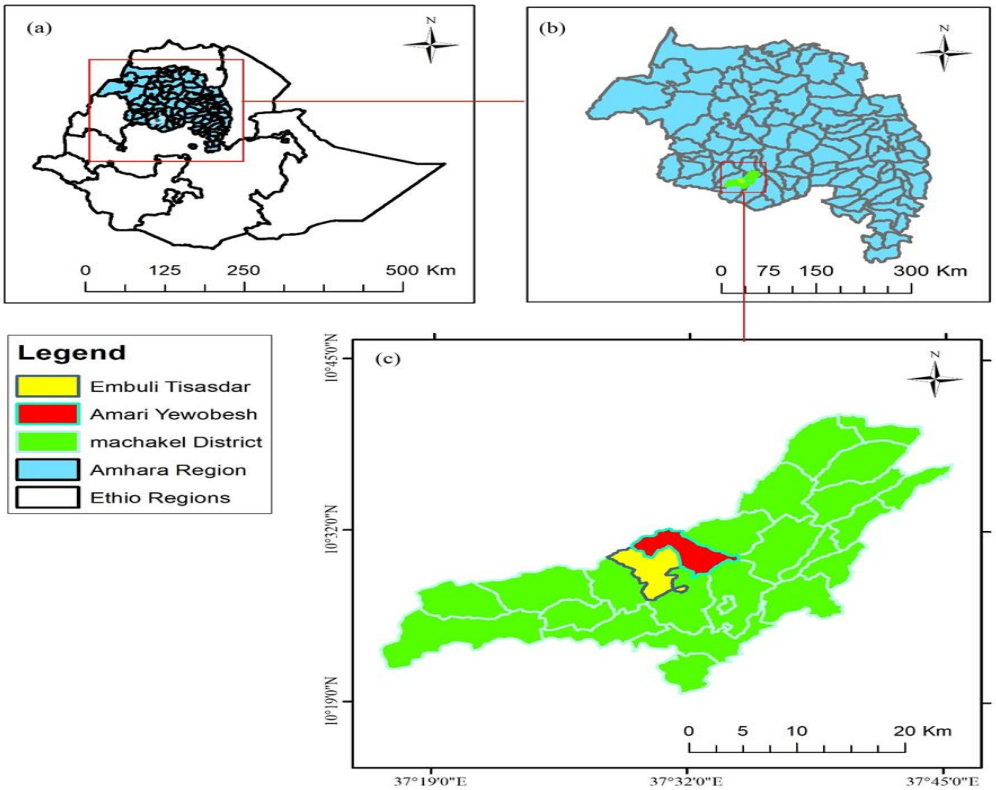


Figure 1: Location map of the study area

Source: Ethio Geospatial data, 2022

### 2.2. Sampling design and techniques

The study used a cross-sectional data type to achieve its objectives. The data collection was conducted from January to March 2022. To obtain a representative sample, a multi-stage sampling technique was employed. First, the Embuli and Yewobesh dairy production and marketing cooperatives were selected randomly from dairy cooperatives that existed in the district. Then, a stratified sampling approach was used due to the heterogeneity of the population in terms of dairy cooperative membership. The farmers having dairy cows in the kebele (lower administrative unit) where the cooperatives are located were divided into two strata: dairy cooperative member farmers and non-member farmers (Table 1). In this study, the researcher's sample population was 796 farmers (farmers having dairy cows). Finally, a total of 266 dairy cooperative member and non-member farmers were randomly selected through the lottery method, with 123 members and 143 non-members, using a probability proportionate to size based on the Kebele and membership.

**Table 1: Distribution of sample respondents among the two Kebeles**

| Kebele | Households having dairy cows | | | Sample households | | |
|---|---|---|---|---|---|---|
| | Non-member | Member | Total | Non-member | Member | Total |
| Embuli Tisasdar | 218 | 120 | 338 | 73 | 40 | 113 |
| Amari Yewobesh | 210 | 248 | 458 | 70 | 83 | 153 |
| Total | 428 | 368 | 796 | 143 | 123 | 266 |

### 2.3. Data type, source, and method of collection

The study collected primary data encompassing both qualitative and quantitative aspects from various sources to ensure a thorough understanding of the research topic. Data were gathered from the sample households through an interview schedule, which allowed for the collection of information on the socioeconomic, institutional, and demographic characteristics of the households. Furthermore, the researchers utilized focus group discussions (4), key informant interviews (10), and field observations to triangulate the data collected through the interview schedule.

### 2.4. Estimation strategy

There might be potential endogeneity issues in dairy cooperative membership; therefore, it is vital to address them. The reason why the cooperative membership variable is endogenous is that joining a dairy cooperative association is self-selection also, all dairy farm households have an equal chance to join an association (Ma et al., 2019; Twumasi et al., 2021). In addition, factors affecting a dairy farmer to join a cooperative may affect household welfare as well. Thus overcoming this endogeneity problem by employing an appropriate econometric model is essential. Propensity score matching (PSM) and endogenous switching regression (ESR) econometric models are widely applied to address endogeneity problems. However, the ESR model was preferred over PSM for this study because: first, it accounts for selection bias by treating selectivity as an omitted variable problem (Heckman, 1979). Second, it also accounts for unobserved characteristics and selection bias arising from both observed and unobserved characteristics (Lokshin and Sajaia, 2004; Shiferaw et al., 2014). Third, ESR helps to capture the different responses from the two groups; thus, a whole sample of members and non-members can be observed (Tesfaye and Tirivayi, 2018).

In the ESR model, there are two stages. The first stage involves modeling the decision to become a member of the dairy cooperative, which is known as the selection equation. In the second stage, the outcome variables are estimated separately for two groups. The selection equation represents a dichotomous choice, where a smallholder farmer decides to join the dairy cooperative if they perceive a positive difference between being a member and not being a member. To represent this decision for a farm household, an indicator variable, $DCi$ , is introduced. $DCi$ takes a value of 1 when the household decides to become a member of the dairy

cooperative, and 0 otherwise. Consequently, there are two possible states: the decision to be a member of the dairy cooperative ($DCi = 1$) and the decision not to be a member ($DCi = 0$). The association of the selection equation with the dairy cooperative can be specified as follows.

$$DCi^{*} = \beta Zi + \delta i \text{ with } DCi = \begin{cases} 1 & \text{if } DCi > 0 \\ 0 & \text{otherwise} \end{cases} \quad [1]$$

A dairy farmer will decide to be a cooperative member ($DCi = 1$) if ($DC^{*} > 0$ ), where $DC^{*}$ represents the expected benefits of being a member of cooperatives compared to non-members. $Z$ is a vector of variables that determine the dairy farmer's association with a cooperative.

In the second step, based on the results of the selection function, two regime equations are specified explaining the outcomes of interest (household income, milk production, and milk productivity). The relationship between a vector of explanatory variables $X$ and the outcome $Y$ can be represented by $Y = f(X)$. The following specification gives the outcome regression equations for the two regimes:

$$\text{Regime 1}: Y_{1i} = \beta_{1i}x_{1i} + \varepsilon_{1i} \quad \text{if } DCi = 1 \quad [2a]$$

$$\text{Regime 2}: Y_{0i} = \beta_{0i}x_{0i} + \varepsilon_{0i} \quad \text{if } DCi = 0 \quad [2b]$$

Where $Y_{1i}$ and $Y_{0i}$ represent outcomes such as household income, milk production, and milk productivity for dairy cooperative members and non-members, respectively. $x_i$ = a vector of the independent variables, $\beta i$ = a vector of parameters to be estimated. $\varepsilon_i$ = a random disturbance term associated with the outcome variables.

To properly identify the model, it is necessary to use variables that directly influence the dairy cooperative membership decision, but not the outcome variables in both regimes, as selection instruments. Therefore, the selection equation is estimated based on all explanatory variables specified in the outcome equations plus one or more instruments. According to Twumasi et al. (2021), Ito et al. (2012), and Ma and Abdulai, (2016) the neighbors' membership variable is used as an identifying instrument because farmers' choice of cooperative membership is positively and significantly influenced by their neighbors' membership. However, neighbor membership is not expected to directly affect household income milk production, and milk productivity. Therefore, for this study, neighbor membership was used as an instrumental variable that appears in the selection equation but not in the outcome equation because of the above rationale. Finally, the error terms are assumed to have a trivariate normal distribution, with zero mean and covariance matrix. Specified as:

$$\text{Cov}(\varepsilon_1, \varepsilon_0, \delta)\begin{pmatrix} {\sigma_1}^2 & \sigma_{10} & \sigma_{1\delta} \\ \sigma_{01} & {\sigma_0}^2 & \sigma_{0\delta} \\ \sigma_{\delta 1} & \sigma_{\delta 0} & {\sigma_\delta}^2 \end{pmatrix} \quad [3]$$

Where, ${\sigma_1}^2, {\sigma_0}^2$ and ${\sigma_\delta}^2$ are the variances of the error terms in the outcome equation of regimes 1 and 2, and the selection equation, respectively. On the other hand, $\sigma_{1\delta} = \text{cov}(\varepsilon_1, \delta)$ and $\sigma_{0\delta} = \text{cov}(\varepsilon_0, \delta)$. However, $\text{Cov}(\varepsilon_1 \text{ and } \varepsilon_0)$ are not defined, as $Y1$ and Y0 are never observed simultaneously (Lokshin and Sajaia, 2004). ${\sigma_\delta}^2 = 1$, because $\beta$ is estimated up to the scalar factor. This structure of the error terms indicates that the error terms of the outcome equation and the error term of the selection equation are correlated, which results in a non-zero expected value of $(\varepsilon_{1i})$ and, $\varepsilon_{0i}$ given $\delta i$ - error term of the selection equation (Abdulai and Huffman, 2014). Therefore, the expected values of the error terms are as follows:

$$E(\varepsilon_1 | DC = 1) = \sigma_{1\delta}\frac{\varphi(\beta xi)}{\Phi(\beta xi)} = \sigma_{1\delta}\lambda_1 \quad [4]$$

$$E((\varepsilon_0 | DC = 0) = \sigma_{0\delta}\frac{\varphi(\beta xi)}{1-\Phi(\beta xi)} = \sigma_{0\delta}\lambda_0 \quad [5]$$

Where $\varphi$ and $\Phi$ are the probability density and cumulative distribution function, respectively, of the standard normal distribution. The ratio of $\varphi$ and $\Phi$ referred to as the inverse Mills ratio $\lambda 1$ and $\lambda 0$ (selectivity terms). If the estimated covariance $\sigma_{1\delta}$ and $\sigma_{0\delta}$ are significantly different from zero (0) the decision to be a member of a dairy cooperative and the outcome variable (household income, milk production, and milk productivity) are correlated. This implies endogenous switching and the presence of a sample selectivity bias due unobservable factor (Maddala, 1986).

In addition, the endogeneity tests $\rho_1$ $(\sigma_{1\delta})$ and $\rho_2$ $(\sigma_{0\delta})$ provide an economic interpretation, depending on the signs. If $\rho_1$ and $\rho_2$ have opposite signs,

farmers decide whether to be members of dairy cooperatives based on comparative advantage (Fuglie and Bosch, 1995). That is, the treatment group enjoys above-average income once it is a member of the dairy cooperative, whereas the control group enjoys above-average income when it is not a member of the dairy cooperative. On the other hand, if $\rho_1$ and $\rho_2$ have the same signs, it demonstrates "hierarchical sorting" (Fuglie and Bosch, 1995). This suggests that the controlled group household income is above the average level regardless of whether they are members of the dairy cooperative but get better off being members than not being members. Moreover, the coefficients $\rho_1$ and $\rho_2$ can provide evidence of model consistency under the condition $\rho_1 < \rho_2$ (Trost, 1981). This implies that the treatment group enjoyed a higher income level than they would if they were not members of the dairy cooperative.

The average treatment effect on the treated group (ATT) is also taken into account in this study. It is calculated by the conditional expectations of the treated group (Equation 6), i.e., those who join cooperatives. It is expressed as;

Farmers with dairy cooperative members:-

$$E(Y_{1i} \mid DC_i = 1) = \beta_1 X_i + \sigma_{1\delta}\lambda_1 \quad [6]$$

Farmers without dairy cooperative members:-

$$E(Y_{1i} \mid DC_i = 0) = \beta_0 X_i + \sigma_{0\delta}\lambda_1 \quad [7]$$

Thus, ATT is derived from the conditional expectations from equations 6 and 7.

$$ATT = E(Y1i \mid DCi = 1) - E(Y0i \mid DCi = 1)$$

$$= X_i (\beta_1 - \beta_0) + \lambda_1(\sigma_{1\delta} - \sigma_{0\delta}) \quad [8]$$

## 3. Results and Discussion

### 3.1. Household characteristics of the respondents

Descriptive statistics of the socioeconomic profiles of members and non-members are presented in Table 2. As observed in the table households in the study area earn on average 62496.21 ETB per annum. Farmers produced 5.605 and 2.955 liters of milk per day and cow, respectively. Significant differences were found between dairy cooperative members and non-members in terms of the outcome variables (household income, milk production, and milk productivity), which indicates that members of dairy cooperatives are better off than non-members. The average age of households in the study area was found 48.58 years implying that the majority of the farmers are in the productive age groups. Of the total sample household 92% were male-headed. The average educational level of households was grade 2.76, and the majority of households (67%) in the study area had neighbor dairy cooperative member farmers.

Overall, members and non-members were significantly different in terms of age, educational level, neighbors' membership, livestock holding, crossbreed cow ownership, extension contact, distance to the district market and milk cooperative, and market information access. Dairy cooperative members are headed by older persons who also hold a higher level of education, as compared to non-members. In addition, the dairy cooperative member farmers had more resource ownership (livestock and crossbred cows) as compared to non-members. Furthermore, the mean distance from the district market was significantly higher, while the mean distance from the dairy cooperative was significantly lower among cooperative members.

**Table 2: Descriptive summary of selected variables used in estimations**

| Variables | Total (N=266) | Members (N=123) | Non-members (N=143) | t-test/ $\chi 2$ value |
|---|---|---|---|---|
| **Outcome variables** | | | | |
| Household income (Ethiopian Birr (ETB)) | 62496.21 | 73478.03 | 53050.3 | -5.53*** |
| Milk production per day (lt) | 5.605 | 8.150 | 2.46 | -13.77*** |
| Milk productivity per cow (lt) | 2.955 | 4.28 | 1.83 | -12.01*** |
| **Explanatory variables** | | | | |
| Sex (male) | 0.92 | 0.94 | 0.90 | 1.52 |
| Age(years) | 45.48 | 47.39 | 43.85 | -3.09** |
| Educational level (Grade completed) | 2.76 | 3.38 | 2.12 | -2.97*** |
| Neighbor membership (yes) | 0.67 | 0.83 | 0.53 | 27.00*** |
| Livestock holding (TLU) | 7.13 | 8.00 | 6.39 | -4.60*** |
| Landholding size (ha) | 1.62 | 1.61 | 1.64 | 0.26 |
| Off-farm participation (yes) | 0.59 | 0.59 | 0.58 | 0.01 |
| Crossbreed cow ownership (#) | 0.83 | 1.37 | 0.36 | -10.57*** |
| Extension contact (#) | 3.73 | 5.12 | 2.52 | -5.13*** |
| Distance to the district market (minute) | 111.11 | 116.91 | 106.12 | -3.73*** |
| Distance to milk cooperative (minute) | 38.32 | 26.21 | 48.74 | 9.18*** |
| Access to credit(yes) | 0.24 | 0.28 | 0.21 | 1.61 |
| Market information access (yes) | 0.61 | 0.93 | 0.32 | 104.09*** |

Note: ** and *** indicate significance at 5% and 1%, respectively

### 3.2. Impacts of dairy cooperative membership and its determinants

Results from the endogenous switching regression models are presented in Tables 3, 4, and 5. The selection equation estimates representing farmers' decision to join a dairy cooperative are presented in the second column of all tables. Estimation results of Equations (2a) and (2b) for household income, milk production and milk productivity are presented in subsequent columns of Tables 3, 4, and 5, respectively.

Likelihood ratio tests for the joint independence of the equations in the ESR specifications of these tables showed that the equations are dependent. This implies that the three equations (the selection equation and outcome equations of members and non-members) were jointly dependent, providing evidence of endogeneity that needs to be controlled in the model specification of household economic welfare equations. The signs and significance of the correlation coefficient between the dairy cooperative membership equation and household income, milk production, and milk productivity for members ($\rho_1$) indicate that self-selection occurred in dairy cooperative membership (Tables 3, 4 and 5) suggesting that the decision to join a cooperative association was not randomly distributed and that a selection bias exists. Thus, the use of ESR, which accounts for both observable and unobservable factors, was appropriate for this study.

The model result shows that the coefficients of most of the variables had the expected signs. Variables such as the age and educational level of the household head, extension contact, distance to the district market, livestock holding, off/non-farm participation, ownership of crossbreed cows, and availability of neighbor dairy cooperative member farmers significantly and positively influenced dairy cooperative membership. In contrast, landholding size and distance to the dairy cooperative significantly and negatively influence the dairy cooperative membership decision.

The age of the household head positively influenced farmers' decision to join dairy cooperatives. Older farmers may be more aware and accumulate knowledge related to the benefits of dairy cooperatives as a result of their longer years of farming experience and networking with other farmers, enabling them more likely to join dairy

cooperatives. The present finding is consistent with the results of Petcho et al. (2019), Ali et al. (2024), and, who explored the positive interaction between the age of the household head and being a member of cooperatives. Similarly, the probability of dairy cooperative membership increased with the years of formal education of household heads. More education is expected to enhance farmers' knowledge about cooperatives and how they would, later on, impact their agribusinesses and household welfare. Moreover, educated household heads may easily understand the opportunity cost of not being a member of dairy cooperatives. The finding confirms the results of Manda et al. (2020), Molla et al. (2024), and Toiba et al. (2024), which showed that a positive and significant association between the educational attainment of household heads and the likelihood of cooperative membership.

Farmers who have more extension contact with development agents were also more likely to influence the probability of cooperative membership. One possible reason is that farmers who are frequently in contact with experts may improve their understanding and benefit from dairy cooperatives to improve their welfare level. The finding is consistent with the idea presented by Wossen et al. (2017), and Jimenez et al. (2018), that regular contact with extension experts encourages farming families to be more receptive to institutional changes or innovations in their production methods. The result also indicates that distance to the district market positively affected the dairy cooperative membership decision of farmers. This implies that farmers far from the district market did not have access to the sale of their dairy products, which pushes them to use dairy cooperatives as their market outlet. This finding is in agreement with those of Tefera and Gebre (2015), and Chagwiza et al. (2016), but contradicts the studies of Verhofstadt and Maertens (2015), Adjin et al. (2020), who revealed that farmers living near the market area are likely to become cooperative members. Thus, farmers far away from dairy cooperatives are beneficial from these cooperative associations.

As expected, total livestock holding and crossbreed cow ownership were found to positively influence dairy cooperative membership. This finding aligns with the empirical results reported by Abebaw and Haile (2013), Mojo et al. (2015), Bayan (2018), and Mammo et al. (2021), which showed that the number of livestock a household owns increases the likelihood of that household becoming a member of cooperative. Furthermore, household heads that had access to market information were more likely to be members of dairy cooperative associations compared to those without market information. It's because, dairy cooperatives help their members to acquire market information related to their dairy production inputs and outputs. Similarly, Dejen and Matthews (2016), and Mammo et al. (2021), pointed out that information access accelerates the decision of farmers to join cooperatives. The dairy cooperative membership status was also found to be positively and significantly influenced by the neighbor's membership variable. This suggests that household heads who have friends or family members who belong to a cooperative association are more likely to become members of that cooperative as a result of building social networks arousing motivation and interest towards dairy cooperatives.

Further, land size influences farmers' membership decisions of the dairy cooperatives negatively and significantly. This implies that, as farm size decreases, the probability of dairy cooperative membership of farmer increases. This indicates that farmers with smaller land holdings are more likely to benefit from dairy cooperatives because they may focus on dairy production for their livelihoods which helps them to be part of dairy cooperatives. Similarly, Kipkogei et al. (2024), revealed farmers prefer group membership as their smaller lands would be productive and profitable only in collaborative groups. The present finding is in line with previous studies by Verhofstadt and Maertens (2014), and Molla et al. (2024), who noted the inverse relationship between land-holding size and dairy cooperative membership.

A negative association was found between farmers' dairy cooperative membership decisions and the variable distance to the dairy cooperative. The result suggests that farmers closer to the dairy cooperative are more likely to join dairy cooperatives. Milk is a highly perishable product which needs to be preserved appropriately by the cooperative. Farmers

far away from dairy cooperatives may incur additional costs to supply the dairy products to the cooperative which increases transaction costs and this may negatively influence their membership decisions.

### 3.3. Effect of dairy cooperative membership on household income

The result indicated that land holding size, livestock holding, and crossbreed cow ownership significantly increase the household income of both members and non-members. The positive and significant coefficient of these variables for both members and non-members suggested that larger land holding size, and owning higher livestock and crossbreed cows improved the income of households. These wealth proxy variables increase agricultural production of crops and livestock sector. This result is consistent with the findings of Adjin et al. (2023), and Kipkogei et al. (2024), both reported that farm size contributes a positive significant role to the household incomes of members and non-members. On the other hand, the coefficients of market information and distance to the dairy cooperative were negative and significant for both members and non-members. The result depicts that as the distance from home to the dairy cooperative increases, household income decreases. A possible explanation for this result is that dairy cooperatives provide marketing (buying and selling of dairy products), breeding, extension, and production (improved feed supply) services to farmers. These services are important for animal production, which increases the income gained from the sector. This finding is consistent with the result of Ahmed and Mesfin (2017) who indicated that distance to the market negatively influences member households' welfare.

Meanwhile, the estimated coefficients for dairy cooperative members and non-members show that there exists some heterogeneity and differences between the two groups of farmers concerning their household income determinants. Unlike farmer members, the household income of farmer non-members also increased with credit access dummy and education of the household head. These results for non-members are interesting because literate farmers may diversify their income sources by practicing any virtue. After all, education increases the risk-taking ability of farmers. Similarly, Ankrah et al. (2021) reported education significantly and positively affects the income of both cooperative member and non-member households.

On the other hand, member farmers' household income was increased by off/non-farm participation dummy but decreased by distance to the district market. The negative sign of market distance indicates that households far from the market incur high marketing and transportation costs for producing and marketing agricultural products making transporting perishable and non-perishable products inconvenient, which reduces household income. This finding is consistent with the results of Ahmed and Mesfin (2017), and Ma et al. (2022), who indicated that distance to the market negatively influences member households' welfare. The positive coefficient of off/non-farm participation implied that farmers involved in off/non-farm activities (petty trade, carpenter, weaver, laborer, preparing local breweries, etc.) will generate additional income for their households.

Furthermore, the analysis indicates that cooperative membership has a heterogeneous impact on household income among its members. It was found that cooperative membership is effective in improving income for households with more land (bigger landholding size), a higher number of livestock, and crossbreed cows.

**Table 3: Determinants of dairy cooperative membership and its impact on household income**

| Variables | Selection equation | Household income | |
|---|---|---|---|
| | | Members | Non-members |
| Sex of household head | 0.0051 (0.4247) | -3468.25 (10391.07) | -67.32319 (7293.84) |
| Age of household head | 0.0714*** (0.0164) | -548.94 (333.58) | -23.3595 (294.1109) |
| Educational level of household head | 0.2876** (0.1391) | -1227.91 (2999.738) | 4791.231* (2816.58) |
| Landholding size | -0.5411** (0.2095) | 9027.77*** (3317.548) | 8730.23*** (3342.78) |
| Extension contact | 1.1258* (0.6111) | -11955.24 (25100.57) | -3145.415 (5199.69) |
| Social responsibility of the household head | 0.2061 (0.2443) | -516.97 (5010.26) | 5761.372 (4658.223) |
| Credit access | -0.1490 (0.2803) | 95.5801 (5643.092) | 10453.35* (6201.20) |
| Distance to the district market | 0.0100* (0.0051) | -187.406** (88.609) | 5.488959 (127.709) |
| Distance to dairy cooperative | -0.0252*** (0.0066) | -378.79*** (140.76) | -517.64*** (126.39) |
| Livestock holding (TLU) | 0.1565*** (0.0584) | 2785.62***(1047.7) | 1952.919** (948.3739) |
| Off/non-farm participation | 0.4924* (0.2551) | 11805.01** (5611.827) | -7381.741 (5048.062) |
| Market information access | 1.6136*** (0.302) | -19598.89* (10258.16) | -14130.93** (5911.91) |
| Crossbreed cow owned | 0.7391*** (0.274) | 13433.54*(7485.046) | 12119.96** (5687.73) |
| Neighbor's membership | 0.7171*** (0.266) | | |
| Cons | -7.88887*** (1.269) | 119269.9 (7157.37) | 46141.12 (23633.16) |
| $\rho_1$ | | -0.70574** (0.18715) | |
| $\rho_2$ | | | -0.05024 (0.19073) |
| Log-likelihood | -3135.495 | | |
| Wald chi2(13) | 64.11*** | | |
| LR test of indep. eqns. :chi2(1) | 4.70** | | |
| Number of obs. | 266 | 266 | 266 |

Note: *, **, and*** denote significance at 10%, 5%, and 1%, respectively; values in the parentheses are standard errors

### 3.4. Effects of dairy cooperative membership on milk production

The ESR model output (Table 4) showed that livestock holding, off-farm participation, and market information access influenced the milk production of dairy cooperative member households positively and significantly. On the other hand, non-members' milk production per day was positively affected by land holding size, the social responsibility of the household head, and credit access. Cross-breed cow ownership of the household had a positive effect on milk production of both members and non-members of dairy cooperatives. Contrary to the variables such as; age of the household head, distance to the district market, and distance to the dairy cooperative reduce milk production of both members and non-members of dairy cooperatives.

As expected, livestock holding positively and significantly influenced the milk production of dairy cooperative member farmers. It indicates that households with higher livestock holding may have higher dairy animals that directly increase their milk production. Unlike non-member farmers, milk production of member farmers increased with milk market information and off/non-farm participation dummy. The result indicates that having sufficient market information helps farmers to identify the appropriate marketing channels provided by cooperatives to sell their products which leads to increased milk production.

Furthermore, land holding size, social responsibility of the household head, and credit access variables positively and significantly increased milk production for non-member farmers. The impact of the variable land holding size was positive and statistically

significant for the non-members. This might be associated with obtaining sufficient animal feeds as a result of allocating land for fodder and grazing or as a form of byproducts from crop production. The present finding is consistent with the previous studies conducted by Olagunju et al. (2021), and Kipkogei et al. (2024), who explored that land size contributed to the highest output for both cooperative member and non-member farmers. Farmers with a social responsibility have easy access to relevant information on how can increase milk production. The crossbreed cow ownership variable had a positive and significant impact on milk production for both members and non-members, reflecting the importance of focusing on quality rather than increasing the quantity of local breed dairy animals.

**Table 4: Determinants of dairy cooperative membership and its impact on milk production**

| Variables | Selection equation | Milk production per day | |
|---|---|---|---|
| | | Members | Non-members |
| Sex of household head | -0.020 (0.422) | -0.821 (1.578) | -0.289 (0.376) |
| Age of household head | 0.069***(0.016) | -0.092* (0.050) | -0.026*(0.015) |
| The educational level of household head | 0.270* (0.139) | 0.003 (0.456) | 0.058 (0.147) |
| Landholding size | -0.523**(0.204) | 0.527 (0.501) | 0.414**(0.172) |
| Extension contact | 1.148* (0.610) | 0.940 (3.903) | -0.110 (0.269) |
| Social responsibility of the household head | 0.181 (0.249) | 0.021 (0.755) | 0.684***(0.240) |
| Credit access | -0.128 (0.281) | -0.305 (0.848) | 0.956***(0.320) |
| Distance to the district market | 0.010** (0.005) | -0.037***(0.013) | -0.015**(0.007) |
| Distance to dairy cooperative | -1.614***(0.303) | -0.043** (0.021) | -0.025*** (0.007) |
| Livestock holding (TLU) | 0.158***(0.057) | 0.400** (0.159) | 0.060 (0.049) |
| Off/non-farm participation | 0.424* (0.247) | 1.774** (0.857) | 0.268 (0.260) |
| Market information access | 1.614*** (0.303) | 3.355* (1.576) | 1.310 (0.311) |
| Crossbreed cow owned | 0.688** (0.275) | 2.348**(1.109) | 1.383***(0.295) |
| Neighbor's membership | 0.710*** (0.266) | | |
| Cons | -7.609*** (1.214) | 14.804*** (5.618) | 0.996 (1.228) |
| $\rho_1$ | | -0.606** (0.205) | |
| $\rho_2$ | | | 0.054 (0.233) |
| Log-likelihood | -643.264 | | |
| Wald chi2(13) | 57.79*** | | |
| LR test of indep. eqns. :chi2(1) | 2.87* | | |
| Number of obs. | 266 | 266 | 266 |

Note: *, **, and*** denote significance at 10%, 5%, and 1%, respectively; values in the parentheses are standard errors

On the contrary, age of the household head, distance to the district market, and distance to the dairy cooperative had a negative and significant impact on milk production for both members and non-members of dairy cooperatives. This suggests that younger farmers increase their milk production. The finding is consistent with Lordkipanidze and Tauer (2000), and Jimenez et al. (2018), which showed that farmers increase their productivity up to mid-life, but then experience a decrease in productivity as they age. It also indicates that farmers who are nearest to the market and the dairy cooperative increased their milk production. This is because farmers can easily access production and marketing services from the market and dairy cooperatives.

### 3.5. Effects of dairy cooperative membership on milk productivity

Table 5 presents the estimates of the impact of dairy cooperative membership on milk productivity per cow. The result revealed that market information and crossbreed cow ownership positively affected the milk productivity of non-members and both member

and non-member farmers, respectively. Contrary to this, the sex of the household head and livestock holding negatively influenced the milk productivity of dairy cooperative non-members and member farmers, respectively. Furthermore, distance to the district market had a negative significant effect on the milk productivity of both member and non-member farmers.

Market information increases milk productivity of non-member farmers, implying that the information gained helps farmers to adopt technologies to improve milk productivity. Both member and non-member dairy farmers' milk productivity has been affected by crossbreed cow ownership. The positive and significant coefficient of the crossbreed cow ownership variable indicates the importance of owning crossbreed cows to increase milk production and productivity.

| Variables | Selection equation | Milk productivity | |
|---|---|---|---|
| | | Members | Non-members |
| Sex of household head | 0.090(0.427) | -0.180 (0.567) | -0.558* (0.312) |
| Age of household head | 0.070*** (0.017) | -0.012 (0.019) | -0.009 (0.012) |
| Educational level of household head | 0.274* (0.139) | 0.005 (0.164) | 0.095 (0.120) |
| Landholding size | -0.505*** (0.202) | -0.134 (0.185) | 0.143 (0.143) |
| Extension contact | 1.164** (0.587) | -0.536 (1.357) | -0.217 (0.223) |
| Social responsibility of the household head | 0.229 (0.247) | 0.158 (0.274) | -0.150 (0.199) |
| Credit access | -0.104 (0.272) | -0.561 (0.307) | 0.241 (0.265) |
| Distance to the district market | 0.009* (0.005) | -0.017*** (0.005) | -0.010* (0.005) |
| Distance to dairy cooperative | -0.021*** (0.007) | -0.009 (0.009) | -0.008 (0.005) |
| Livestock holding (TLU) | 0.121** (0.050) | -0.167*** (0.062) | -0.044 (0.040) |
| Off/non-farm participation | 0.571** (0.268) | 0.392 (0.306) | 0.287 (0.215) |
| Market information access | 1.592*** (0.293) | -0.583 (0.632) | 1.088*** (0.250) |
| Crossbreed cow owned | 0.850*** (0.294) | 2.196*** (0.403) | 1.431*** (0.244) |
| Neighbor's membership | 0.814*** (0.286) | | |
| Cons | -7.970*** (1.247) | 8.251*** (2.291) | 1.191 (0.995) |
| $\rho_1$ | | -0.713* (0.243) | |
| $\rho_2$ | | | 0.243 (0.182) |
| Log-likelihood | -489.559 | | |
| Wald chi2(13) | 111.62*** | | |
| LR test of indep. eqns. :chi2(1) | 4.35** | | |
| Number of obs. | 266 | 266 | 266 |

Note: *, **, and*** denote significance at 10%, 5%, and 1%, respectively; values in the parentheses are standard errors

The coefficient of the sex variable is negative and significant for the non-members. Suggesting that female-headed farmers are exclusively engaged in animal production particularly dairy than crop production. Their livelihood is dependent on their dairy activity which is why they improved milk productivity of cows through improved management. The distance-to-market variable appears to have an inverse relationship with milk productivity for both member and non-member farmers. This indicates that market infrastructure is a crucial attribute for milk productivity since production inputs to increase productivity are bought from the market. The livestock holding variable has a negative significant impact on milk productivity for member farmers. The result suggests that farmers with large livestock ownership may face feed shortages that reduce the milk productivity of cows.

### 3.6. Impact of dairy cooperative membership on household income, milk production, and milk productivity

The analysis used the average treatment effect on the treated (ATT) approach, which accounts for potential selection bias from both observable and unobservable characteristics. This allows the study to isolate the true impact of dairy cooperative membership. The results show that dairy cooperative membership has a substantial positive effect on household income. Specifically, membership increases household income by 6,188.57 ETB, which is approximately 9.19 percent higher than the income of non-member households. In other words, if the non-member households had been members of the dairy cooperatives, their household incomes would have been around 9 percent higher. This demonstrates the significant welfare gains that cooperative membership can provide to smallholder dairy farmers.

The findings of the present study are consistent with the results reported in previous research conducted across several developing countries. Studies by Verhofstadt and Maertens (2015) in Rwanda, Mojo et al. (2017) in Ethiopia, Bayan (2018) in China, Ankrah et al. (2021) in Ghana, and Olumeh and Mithöfer (2024) in Malawi have all found that cooperative membership significantly increased the household incomes of member farmers compared to non-members. The alignment between the current study's conclusions and these earlier research outputs helps strengthen the understanding that dairy cooperative participation has a positive impact on improving household income. This aligns with insights from research like the Minah (2022) study, which found that cooperative membership enabled farmers to focus more on marketing functions. By providing access to markets, information, and other essential services, the cooperatives seem to be allowing members to capture a greater share of the value in dairy value chains. Similarly, studies on coffee farmer cooperatives have found that the income effects of cooperative membership improved the purchasing power of members, allowing them to acquire more diverse and adequate food from the market (Shumeta and D'Haese, 2018). This could also help explain the income gains seen in the current study. Furthermore, research by Ma et al. (2018) revealed that cooperative membership can also provide members with access to off-farm jobs through social networking with other members, which in turn boosts overall household income.

As depicted in Table 6, dairy cooperative membership has a significant positive impact on both milk production and productivity for member farmers. Specifically, cooperative participation increased milk production by 68.57 percent and milk productivity by 21.68 percent. These findings align with evidence from previous studies, such as; Bhattacharjee (2023) in India, Onyango et al. (2023) in Kenya, Ng'ombe et al. (2024) in Zambia, and Toiba et al. (2024) in Indonesian, which also reported that cooperative membership improved dairy production and productivity outcomes. Dairy cooperatives appear to be an effective institutional arrangement for boosting the productivity and output of the dairy farming community, which then translates to improved household livelihoods.

**Table 6: Impact of dairy cooperative membership on household income, milk production, and milk productivity**

| | Mean outcome | | ATT | ATU | t-value | Change (%) |
|---|---|---|---|---|---|---|
| | Member | Non-member | | | | |
| Household income | 73546.87 | 67358.30 | 6188.57 | 32105.2 | 4.05*** | 9.19 |
| Milk production | 8.159 | 4.84 | 3.319 | 7.029 | 15.7*** | 68.57 |
| Milk productivity | 4.282 | 3.519 | 0.763 | 2.631 | 7.5*** | 21.68 |

Note: *** denote significance at 1%

## 4. Conclusion

The study showed a greater role of dairy cooperatives in increasing household income, milk production per day, and milk productivity per cow. Being a member increased household income by over 9%, milk production by almost 70% and milk productivity by over 21%. These are sizable gains that demonstrate

the transformative potential of dairy cooperatives. The authors argue these production and income gains then enable farmers to further invest in new technologies and farm inputs, creating a positive reinforcing cycle. This underscores how cooperatives can drive sustainable agricultural development at the household level. Overall, the study provides rigorous empirical evidence that current dairy cooperatives are playing a vital role in boosting the productivity, output, and livelihoods of smallholder dairy farmers. This has important implications for rural development policy.

Thus, based on the findings, this study suggests the following recommendations. First, membership in dairy cooperatives and households' economic welfare had positive and significant associations. Therefore, stakeholders should support dairy cooperative associations to make them more attractive and sustainable for farmers. Second, through dairy cooperative groups, farmers can gain improved access to critical inputs like credit, breeding services, feed, and veterinary care, as well as better market outlets. This suggests cooperatives should be supported and strengthened by the cooperative agency as a mechanism to enhance smallholder dairy farmers' access to essential resources and markets. Third, the government, NGOs, and dairy cooperatives should work on improving asset ownership (e.g., crossbreed cows) and establishing milk collection sub-centers would help to improve farm households' economic welfare. This would help leverage the welfare-enhancing potential of dairy cooperative membership. Finally, the authors note that this study was limited to one region (one district) due to resource constraints. They suggest future research should be expanded to a larger, potentially nationwide, sample. This would provide a more comprehensive understanding of how dairy cooperatives are impacting farmer welfare across the country.

**Data availability statement**

Data will be made available on request.

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**Conflicts of interest**

The authors declared that there is no conflict of interest.

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