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THE IMPACT OF DAIRY COOPERATIVES ON MILK PRODUCERS' REVENUES OF IHUZA ABOROZI BA KIJYAMBERE BAFATANYINJE (IAKIB) IN GICUMBI DISTRICT OF RWANDA. APPLICATION OF PROPENSITY SCORE MATCHING (PSM)

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Abstract. Dairy cooperatives should have a significant impact in the future in terms of regenerating rural life. The pressing need in the Cooperative sector in the era of liberalized environments is to seize every opportunity available for the country. Diary co-operatives mainly from cattle production played a vital role in our country's economy in the previous era and will do so in years to come. This study aims to assess the impact of dairy cooperatives on milk producers' revenues in the Gicumbi district of Rwanda. The total sample involved in this research was 974, from four cow milk producers, namely Bukure MCC-Cooperative d'Elevage Moderne de Bukure (COOPEMOBU), Koperative Zamuka Mworozi (KOZAMGI) and Borozi Twisungane Kabuga-Nyamiyaga and Giramata, which form the cooperative union of Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB). The total sample size to be taken from three cooperatives and other recorded local farmers supplying their milk to the nearest Milk Collection Centres, as preselected, is 260 milk producers, including 187 participants and 73 non-participants of dairy cooperatives. The study used a descriptive survey design, encompassing three cooperatives and other dairy producers not members of cooperatives from Gicumbi district. Descriptive statistics, t-test, Standard Deviation, means, frequency and percentages, as well as a Propensity Score Matching model were used to analyse the results of the study. The study findings show that the average total gross revenue was 551,113 Rwandan francs for these farmers, while the mean difference between dairy cooperative participants and non-participants ranged from 50,146 Rwandan francs to 168,145 Rwandan francs as program impact. This is an indication that participants in dairy cooperatives gain more compared to their factual group. The study recommends that small holder dairy producers should be supported to enable them to produce surplus milk for markets and reduce local milking cow numbers by replacing them with crossbred cows. It is recommended that governments should also strengthen milk processing cooperatives and improve their infrastructure facilities to reduce the transportation cost for small-scale dairy producers.

Keywords: dairy cooperatives, livestock producers and Propensity Score Matching (PSM)

INTRODUCTION

According to the latest report from the Food and Agriculture Organization (FAO), global milk production in 2019 reached 852 million tonnes, an increase of 1.4% on 2018. The statistics from the Food and Agriculture Organization showed that over the last three decades, world milk production has increased by more than 59 percent,

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from 530 million tonnes in 1988 to 843 million tonnes in 2018, while in Africa, milk production is growing more slowly than in other developing regions because of poverty, and in some countries, adverse climate conditions (Stasinakis et al., 2022; Faye and Konuspayeva, 2012).

Dairy production remains an important livelihood option for many poor rural households in the developing world, providing an important source of nutrients and contributing to household income (Duncan et al., 2013). The dairy sub-sector plays an important role as a source of income, which farmers can use for purchasing food and other household assets (Covarrubias et al., 2012). Dairying is one of the investment areas in the livestock sector that farmers can venture into to improve their standard of living (Nkwasibwe et al., 2015). In East Africa, especially in Uganda, the dairy sub-sector accounts for approximately 50% of total output from the livestock sector, 20% of the food processing industry, and 4.3% of the national Gross Domestic Product (National Development Plan 2010) and in Salami et al. (2010), thus the dairy sub-sector acts as a source of food, income, and employment (Pingpoh et al., 2019) and (Sikawa and Mugisha, 2011). This growth rate has been attributed to the favourable macroeconomic policy environment and institutional reforms including the privatization of the dairy sub-sector (Nkwasibwe et al., 2015), increased demand for milk from both consumers and milk processing plants, better herd management, adoption of improved breeds, and improved animal health and support services (Mbowa et al., 2012).

Furthermore, the study conducted by Pica-Ciamarra et al. (2011) ascertained that livestock ownership contributes to household livelihoods in a variety of direct and indirect ways. Firstly, livestock provide cash income or income in kind through the sale of animals and / or the sale and consumption of milk, meat, eggs and other animal products. Secondly, livestock are a form of savings (capital growth through herd growth) and insurance, as the sale of animals provides immediate cash to deal with significant or unexpected expenditures (for example, school or medical fees) (Lekobane and Seleka, 2017). Thirdly, livestock provide manure, draft power and transport services, which can be used on the household farm or exchanged on the market (for example, rental of bull for ploughing) (Lisson et al., 2010). Fourthly, being a source of wealth, livestock not only contribute to social status but may facilitate access to financial services, both in formal and informal markets (Biyase and Zwane, 2018). Finally, because some livestock can be kept close to the homestead and require little labour input, such as a small flock of poultry birds, these can be tended by women while managing other time-consuming activities (for example, cooking or childcare), thereby falling under their control and providing some degree of empowerment (Westholm and Ostwald, 2020). Given these diverse outputs, which comprise both monetised and non-monetised goods and services, it is difficult to quantify the overall contribution of livestock to household livelihoods, and only few researchers have tried to do so (Du-Pont et al., 2020).

According to Germain et al. (2018) and Otieno (2020), Rwanda produces around 185 million liters of milk annually (data, estimates), which translates into an average daily yield per cow of just 3.2 liters, an unsurprisingly low yield given that improved breeds constitute less than 10% of the 157 thousand milking cattle in the country, and given that their nutrition is inadequate (Germain et al., 2018). While the government is undertaking a number of initiatives to improve the dairy sector (e.g. "One cow, one household", which aims to alleviate rural poverty by providing a heifer for each family), the challenges in implementing the policy mean that it will take time to effect widespread change. The dairy industry remains a key livestock component, making a significant contribution to food security and income in Rwanda's pastoral communities. Dairy policies have been relaxed to allow market forces to determine farm level prices in order to increase the level of income for dairy cooperative participants (Germain et al., 2018). Thus, each dairy farmer is different in many aspects, including resource ownership, market orientation (commercialization), access to services, etc., which contributes to different decision-making behavior and participation levels. No specific study has been conducted in Rwanda to assess the impact of dairy cooperatives on livestock milk producers' revenues. This study needs to be conducted in districts of Rwanda, not only for scholarly benefit, but also for that of the dairy cooperative sector to assess the areas and sectors with interventions

OBJECTIVES OF THE STUDY

The aim of this study was to assess the impact of dairy cooperatives on livestock milk producers' revenues from the Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB) in the Gicumbi district of Rwanda through the use of Propensity Score Matching (PSM).

HYPOTHESIS OF THE STUDY

The Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB) do not increasing revenues of livestock producers in Gicumbi district. This is explained by the use of Propensity Score matching (PSM) to justify the effect on participants and non-participants

METHODOLOGY

Description of the study area

The study was conducted in the Gicumbi district of Northern Province, Rwanda. It is the highest milk-producing province, with the best quality of milk produced in terms of water content, acidity, and microbial contamination (Kayigema et al., 2014). The formal farmers' cooperatives that this study focuses on comprise Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB). Targeted milk producers were sourced from 21 sectors of Gicumbi district, such as Bukure, Bwisige, Byumba, Cyumba, Giti, Kaniga, Manyagiro, Miyove, Kageyo, Mukarange, Muko, Mutete, Nyamiyaga, Nyankenke II, Rubaya, Rukomo, Rushaki, Rutare, Ruvune, Rwamiko and Shangasha. A map (Fig. 1) indicating sampled milk producers by sector is shown below.

Land use/land cover of the study area

In Gicumbi district, as in Rwanda as a whole, agriculture is the dominant land use. An overview of the main land use and land cover, obtained from the Rwanda Water

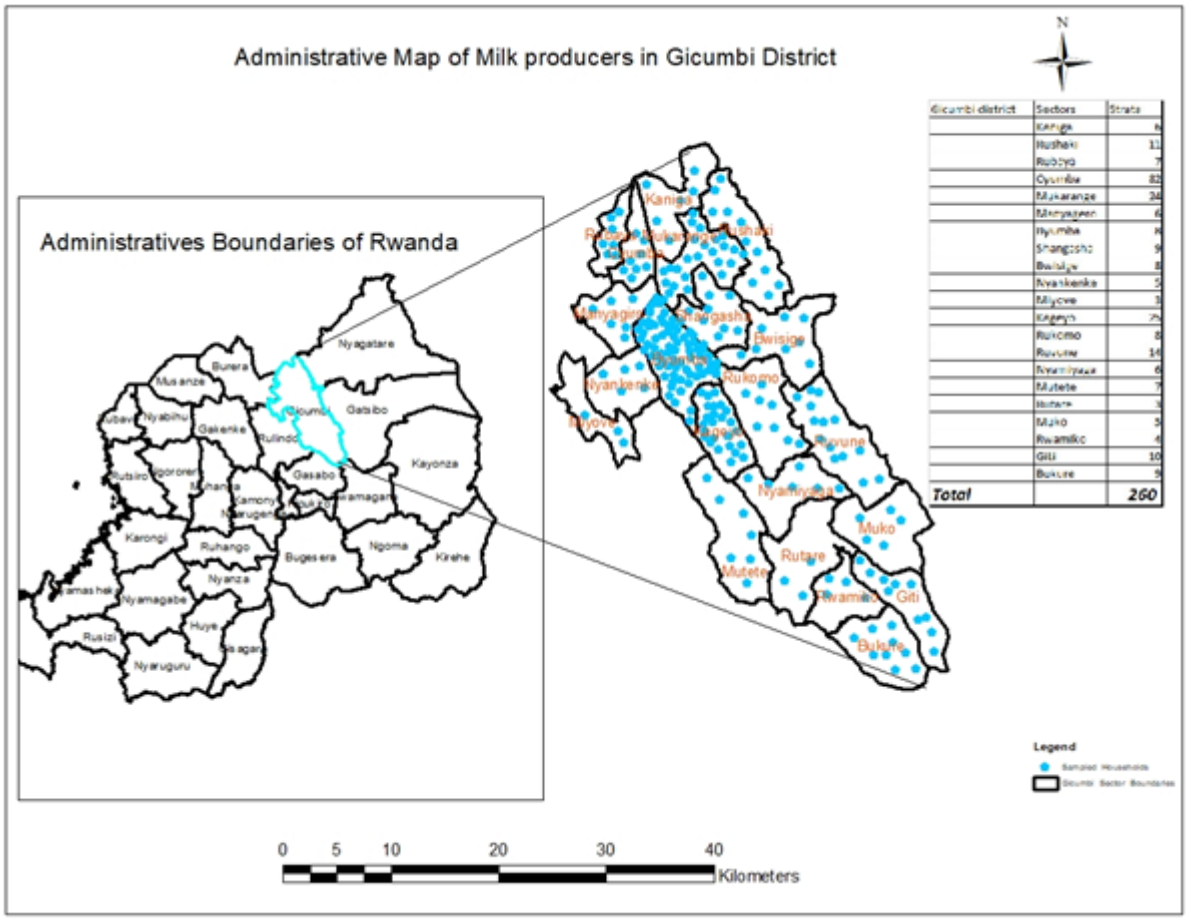

Fig. 1. Administrative map of Gicumbi district (milk producers by sector)
Source: application of Arc GIS 10.7.

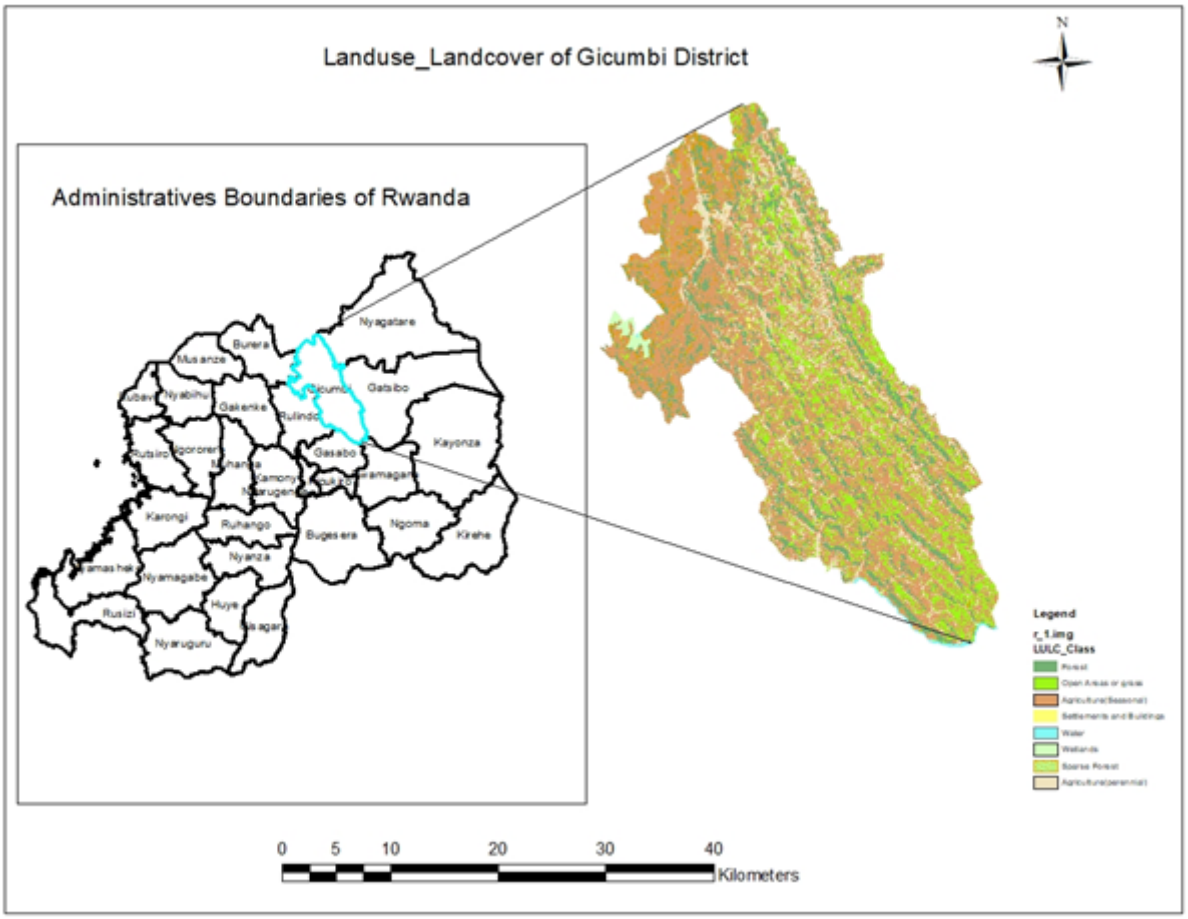

Fig. 2. Land use/land cover of Gicumbi district
Source: application of Arc GIS 10.7.

and Forestry Authority (RWFA) database, is provided in Fig. 2. Other land use classes in the study area are forests, irrigation, built-up areas and open lands. Due to its favourable topography and climate, the district is the largest recipient of Girinka cows in the Northern Province, having received 11,403 cows, and is the highest milk-producing province, with the best quality of milk produced in terms of water content, acidity, and microbial contamination (Kayigema et al., 2014). Dairy farmers practise zero-grazing. The formal farmers' cooperatives to be focused on during this study included: Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB, Cooperative for Modern Farmers); Bukure MCC-Cooperative d'Elevage Moderne de Bukure (COOPEMOBU)-Rwesero; Koperative Zamuka Mworozi (Kozamgi)-Rutare; Borozi Twisungane Kabuga-Nyamiyaga, and Giramata. According to Land O'Lakes (2015), IAKIB is the largest cooperative in terms of membership (292 men and 392 women) and daily milk supplies (22,864 litres). The study targeted members of this cooperative together with service providers and producers in Kageyo, one of the sectors in Gicumbi district.

Total population of the study area

According to Kothari et al. (2005), population is defined as the totality of persons and objects with which the study is concerned. It is a group of individuals, objects or items from which samples are taken (Klenke, 2016). Because of limited budgets and the remoteness of milk producers, the study was conducted in three dairy cooperatives and with other external milk producers pre-selected as non-cooperative members supplying

their milk quantity to nearby Milk Collection Centres (MCC), either to IAKIB (with 684 members including 292 men and 392 women), or COOPEMOBU from Bukure MCC, with 150 members, or KOZAMGI with 140 members. The total population under consideration totalled 974 dairy producers operating in Gicumbi district, including local farmers supplying their milk to the Milk Collection Centre (MCC).

SAMPLE SIZE DETERMINATION AND SAMPLING TECHNIQUES

According to Malterud et al. (2016), the desired sample size is determined by the formula developed by Sloven. Two-stage sampling was used during sample selection. The first stage involved selecting cooperative of Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB) out of three (3) cooperatives. The second stage consisted of selecting members and non-members of dairy cooperative to form a total sample size of 260 as the target respondents. Thereafter a simple random sampling technique employing the ballot-box raffle draw method was used. The total sample size consisted of 260 milk producers from the above area. The mathematical formula developed by Sloven was then used as follows:

$$n = \frac{N}{1 + N(\alpha)^2} \quad (1)$$

where: N – represents the target milk producers and is equal to 974, n – is the sample size and is the margin error. Then α is the margin error (for a confidence interval of 95%, equal to 5% significance level).

$$n = \frac{974}{1 + 974(0.05)^2} = 260 \quad (2)$$

Thus the total sample size to be taken from three cooperatives and other recorded local farmers supplying their milk to nearest Milk Collection Centres (MCC) as pre-selected is 260 dairy producers who are members of IAKIB including 187 members and 73 non-members of IAKIB as a cooperative union producing and supplying much quantity of milk to local and surrounding milk. The purposive sampling technique was used in selecting the Gicumbi district due to its potentiality in milk production after Nyagatare of Rwanda.

Source of data

Primary data related to the quantity of milk supplied to the nearest milk collection centre, market price and revenues were collected from the livestock farmers through the use of structured questionnaires. The stratification sampling technique was applied to select respondents in each sector indicated (see Fig. 1).

Application of propensity score matching model

For Propensity score matching, the dependent variable to be used for the Psmatch2 estimator is membership of IAKIB or not, which takes values 1 or 0. The probit model is a statistical probability model with two categories in the dependent variable and was first used to predict the probability of participation. Probit analysis is based on the cumulative normal probability distribution. The cumulative probability distribution function (F) is then expressed as follows:

$$Prob(Y_i = 1) = \varnothing(\beta_i X_i) = \int_{-\infty}^{X_i} 2\pi^{-0.5} \exp\left(-\frac{X_i^2}{2}\right) dX_i \quad (3)$$

For calculating the impact of the dairy cooperative on farmers' revenues, the Propensity Score Matching Model was used. The dependent variable used for the Psmatch2 estimator (1 = yes and 0 = no) was used to differentiate participants and non-participants. The model was executed and edited data from SPSS to be analysed by means of STATA version 13 computer software using the propensity scores matching algorithm developed by Leuven and Sianesi (2003).

Yi denotes an outcome of interest so that potential outcomes are defined as *Yi* (*Di*) for every household. The treatment effect of the programme for household *i*, *τi*, is then the change in the outcome measure caused by the dairy cooperative participation: *τi* = *Yi* (1) – *Yi* (0); where: *ΔiYi* – denotes the change in the outcome variable of household *i*. Two means are common in the influence analysis framework: the average treatment effect (ATE) and the average treatment effect on the treated (ATT). In the case of a cooperative, ATE estimates the effect of cooperative membership on the outcomes of the whole population without regard to the intervention program, but the ATT estimates the impact of cooperatives in milk production. It is the latter which this study seeks to estimate, and this is represented as follows:

$$ATT = E(\Delta_i \mid I_i = 1) = E[Y_{1i} - Y_{0i} \mid I_i = 1] = \\ = E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 1] \quad (4)$$

From equation (4), $E[Y_{0i} \mid I_i = 1]$ is the missing data representing the outcomes of the participants of this study. By using the outcomes of non-participants, (4) can be rewritten as

$$E(\Delta_i \mid I_i = 1) = E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 1] \quad (5)$$

Without controlling for the unobservable heterogeneity, (5) can be shown to consist of a bias in addition to the impact estimate. Subtracting and adding the right-hand side of (5) gives:

$$= E[Y_{1i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 0] - E[Y_{0i} \mid I_i = 1] + \\ + E[Y_{0i} \mid I_i = 1] \quad (6)$$

$$= E[Y_{1i} - Y_{0i} \mid I_i = 1] + E[Y_{0i} \mid I_i = 1] \quad (7)$$

Bias

Rearranging (5) gives:

$$= E[\Delta_i \mid I_i = 1] + \{E[Y_{0i} \mid I_i = 1] - E[Y_{0i} \mid I_i = 0] \quad (8)$$

$$\{E[Y_{0i}], I_i = 1, X_i = x\} = \{E[Y_{0i}], I_i = 0, X_i \approx x\} \quad (9)$$

In PSM, cooperative participation characteristics are used to estimate a single value (P-score), which serves as the basis for comparison rather than the characteristics themselves. The latter could be very laborious, hence PSM solves the "curse of dimensionality". Once common support is established for the participants in a dairy cooperative, the heterogeneous impact (ATT) of the cooperative on household income can then be estimated using equation (10).

$$ATT = [E(\Delta_i \mid I_i = 1)] = 1/I_i \sum(Y_{0i})I_i = 1/I_i \sum \Delta_i I_i \quad (10)$$

Nearest neighbour matching (NNM)

A case in the control group is matched to a treated case based on the closest propensity score. Each person in the treatment group chooses individual(s) with the closest propensity score to them. Radius matching uses not only the closest NN within each calliper, but all the individuals in the control group within the calliper.

Kernel matching (KM)

The KM uses weighted averages of all cases in the control group to estimate counterfactual outcomes. The weight is calculated by the propensity score distance between a treatment case and all control cases. The closest control cases are given the greatest weight. Each person in the treatment group is matched to a weighted sum of individuals who have similar propensity scores with the greatest weight being given to people with closer scores.

Radius matching (RM)

Radius match estimates average treatment effects (ATET, ATENT, and ATE) of treated variable for a set of outcomes variables outcome using radius matching. Independent variables are used to compute the propensity score. Radius match is a one-to-many calliper matching algorithm as discussed by Rosenbaum and Rubin (1985), for example, and used by (Dehejia and Wahba, 2002). Calliper or radius matching uses all comparison observations within a predefined distance around the propensity score or based on the Mahalanobis distance of the respective treated and control groups.

RESULTS AND DISCUSSION

Gender of respondents

Fig. 3 pertains to the distribution of farmers by gender. As indicated in Fig. 2, about 82% of the total sample was male, while 18% were female. The low rate of women's participation in the dairy sector is a fact in Rwanda, as in many other contexts, women have more limited access

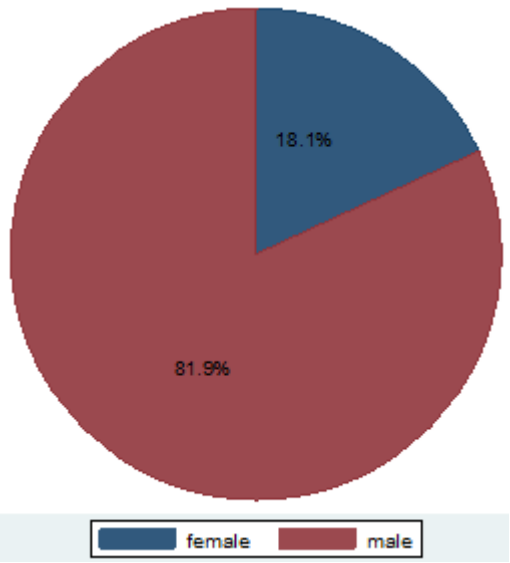

Fig. 3. Distribution of dairy producers by gender
Source: own data, 2020.

to the knowledge, resources and skills needed for livestock production compared to men. Women face higher rates of illiteracy, which makes it harder for them to make use of financial services and understand animal husbandry training. These findings are in line with the study conducted by Umuzigambeho (2017), who found that women are less involved in the dairy sector due to their higher workload than men, as they are responsible for both productive and reproductive impacts within the household, and makes it difficult for them with regard to expanding dairy production.

Marital status of dairy farmers

Fig. 4 indicates the distribution of sampled farmers by marital status. Findings from descriptive statistics indicated that a high proportion of respondents are married, with about 73% of the total sample being married and 27% single. This is consistent with the results reported by Adebayo (2010), and implies that the adoption of technology can succeed, as the study area has stable and available labour force (married) instead of having many young people who always move to look for employment elsewhere.

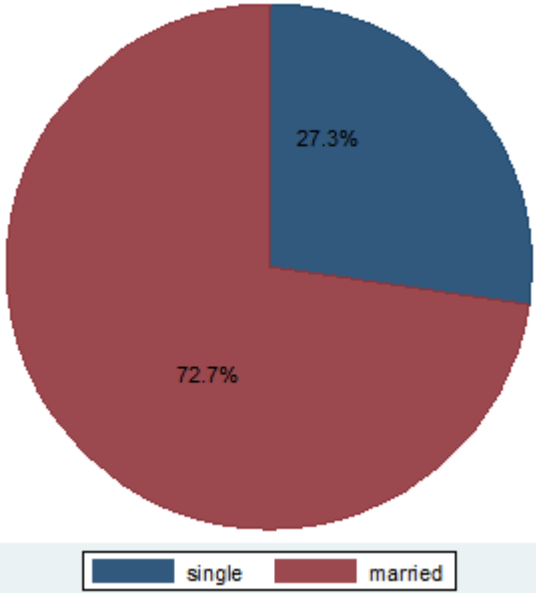

Fig. 4. Distribution of dairy producers by marital status
Source: own data, 2020.

Descriptive statistics of age, family size, education, experience and farm size

Table 1 pertains to the socio-economic characteristics of the respondents from Gicumbi district, and these include age, family size, education, and experience and farm size. According to Table 1, the average age was higher (49.67 years) for participants of dairy cooperatives, while the non-participants were aged 49.88 years compared to cooperative member farmers. The t-value was not statistically significant with *p*-value = 0.878 and t-stat = –0.15. The age of the household head is very important when it comes to decision making. Older farmers are deemed more experienced than younger farmers, who are known to be risk-takers. Our findings agree with the Rwandan national statistics by NISR (2016), where the majority of agricultural operators in Rwanda were in the age-group of 45–55 years.

For household size based on a comparative study of participants and non-participants in dairy cooperatives, statistics showed that the majority of participants comprised 8.18 members, while the non-participants comprised 7.52 members and had fewer members than household members engaged in dairy cooperatives. The t-stat of 1.83 and p-value of 0.068 was statistically significant. This can be a source of family labour and therefore a key input in dairy production.

The results presented in Table 1 indicate that a majority of farmers interviewed are mainly literate, and this goes for both cooperative participants or non-participants; however, cooperative members have a lower number of years spent at school, not literacy rate (10.59 years) than non-coop members with education level of 12.7433 years. The t-test of –2.72 and p-value 0.007 were statistically significant at the 5% level of significance, which indicates that there is no significant difference in the education level between cooperative member farmers and independent farmers. This implies that relatively educated farmers participate in cooperatives. In the context of Rwandan agriculture, educated farmers with primary level education constituted 66.6% of agricultural operators, while 25.9% had no education, 6.5% attended secondary level education and only 1.0% had attended tertiary level education (NISR, 2016). Table 1 also shows the experience in dairy cooperative participation from Gicumbi district. The average number of years of membership of a dairy cooperative is 2.262 years. When compared to the factual group, the mean years spent in dairy production was 1.9358 years and

Table 1. Summary statistics of age, family size, education, experience, and farm size

Variables	U/M	Mean		% Reduction		T-Test		V(T) / V(C)
		treated	control	% bias	|bias|	T-stat	P > |t|	
Age	U	49.674	52.082	–18.3		–1.32	0.188	1.03
	M	49.674	49.882	–1.6	91.3	–0.15	0.878	1.06
Family size	U	8.1818	7.5205	20.3		1.47	0.142	0.96
	M	8.1818	7.5348	19.8	2.1	1.83	0.068	0.81**
Education	U	10.5882	12.4247	5.2		0.39	0.697	0.73
	M	10.5882	12.7433	–36.7	–606.1	–2.72	0.007	0.33**
Experience	U	2.262	1.7671	31.2		2	0.047	4.57**
	M	2.262	1.9358	20.6	34.1	1.95	0.052	3.78**
Farm size	U	2.2419	1.8811	22.1		1.47	0.143	2.45
	M	2.2419	2.1992	2.6	88.2	0.22	0.825	1.21

U – Unmatched, M – Matched.
**Corresponds to significance levels at 5%.
Source: own data, 2020.

experience in dairy experience was found to be statistically significant at a 5% level of significance (t-value = –1.95 and p-value = 0.052). The explanation for this is that those early adopters (farmers with having more experience in dairy production) have an advantage to earn from rearing cattle dairy than non-participants in such cooperatives. If the farmers follow learning approach, increase in experience is expected to lead to increased participation and intensity of participation.

Furthermore, the findings presented in Table 1 indicate that the average farm size holding was 2.2419 ha for pastures and other arable area under crop production for cooperative members and 2.1992 ha for non-cooperative members in Gicumbi district. The mean difference in the t- test values between participants and non-participants in dairy cooperatives in terms of farm size was found not to be statistically significant at the 1%, 5% and 10% level of significance (t-value = 0.22, p-value = 0.825). The findings from this study also conflict with the reports by Kathiresan (2012) and Bizoza and Havugimana (2013), where the authors indicate that the land holding capacity for small-scale farmers in Rwanda is 0.7 ha per household.

Effect of the IAKIB dairy cooperative on livestock producers' revenues in Gicumbi district

To determine the effect of the IAKIB cooperative on livestock producers' revenues, it was necessary to compare the observed outcomes for this variable with the outcomes that would have been obtained for those same households over the same time period if they did not participate in the dairy cooperative. The important next step is to consider the ATT values (Average Treatment effect on the Treated) by comparing revenues from dairy cooperative participation (treated and control group) on the basis of their propensity scores based on three matching algorithms nearest neighbour matching (NNM), kernel matching (KM) and radius matching (RM). For gross revenues analysis as the effect of participation in dairy cooperative, the average total gross revenue was 551,113 Rwandan francs (Rfs) for treated farmers, while the mean difference between dairy cooperative participants and non-participants ranged from 50,146 Frws, 168,145Frws and 167,404 Rwandan francs (Rfs) using nearest neighbour matching (NNM), kernel matching (KM) and radius matching (RM). Moreover, all estimates were statistically significant at the 5% level of significance with t-stat ranging from 2.96**; 2.22** and 2.81**, respectively. Higher gross farm revenues and lower cost investment are benefits for dairy cooperative members compared to counterfactual groups with higher expenditures and lower revenues. When the household had more milking cows, the probability of milk marketing increased, which in turn increased the level of household revenues. These findings are coherent with the research conducted

Table 2. Effect of IAKIB milk cooperative on livestock producers' revenues in Rwanda

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Nearest neighbour matching (NNM)						
Revenues	Unmatched	551,113.33	383,624.14	167,489.20	88,803.30	1.89**
	ATT	551,113.33	500,967.70	50,145.63	81,560.09	2.77**
Kernel matching (NNM)						
Revenues	Unmatched	551,113.33	383,624.14	167,489.20	88,803.30	1.89**
	ATT	551,113.33	382,967.91	168,145.43	75,568.56	2.23**
Radius matching (RM)						
Revenues	Unmatched	551,113.33	383,624.14	167,489.20	88,803.30	1.89**
	ATT	551,113.33	383,709.52	167,403.81	75,460.36	2.22**

**Corresponds to significance levels at 5%.
Source: own data, 2020.

by Sharma and Das (2018), who concluded that farmers participating in dairy cooperatives earn more than the control group. In addition, the similar findings were obtained in Ethiopia by Lenjiso et al. (2016), who suggested that cow ownership and increased dairy production can lead to improved child nutrient intake. Similar findings also were obtained by Mwabonimana et al. (2015) in Rwanda by comparing the cost and benefits from livestock rearing.

Density distributions of the estimated propensity scores of two groups

To estimate ATT, the mean difference in outcomes for dairy cooperative participant and nonparticipant households after matching, three matching algorithms including nearest neighbour matching and kernel matching and radius matching were used. According to De Hoop (2012), using both nearest neighbour matching with replacement, kernel matching and radius matching provides a natural robustness check to guard against the disadvantages of the three matching algorithms. Thus, based on the findings presented in Fig. 5, it is clear that 3 treated individuals and one untreated did not receive matching. The ATT values presented in Table 3 and the results of the balancing test of the commonly supported assumption show that both groups do not have the same distribution in covariates after matching. The graph shows that no treated and untreated individuals are found out of the support region and these data

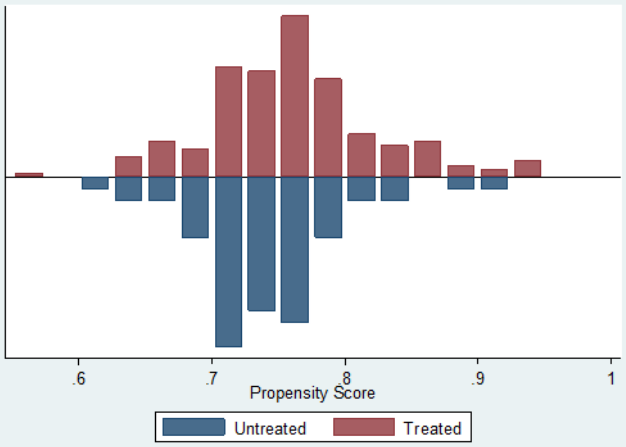

Fig. 5. Density distributions of the propensity scores for the two groups
Source: own data, 2020.

indicate that all the treated and untreated milk producers are found in the support region.

Assessing the balancing test of common support

Assessing balance involves assessing whether the distributions of covariates are similar between the treated and control groups. Referring to the findings presented in Table 3 after running nearest neighbour matching (NNM), kernel matching (KM) and radius matching (RM), it was

Table 3. Balancing test of common support

Psmatch2: Treatment assignment	psmatch2: Common support		Total
	off support	on support	
Untreated	1	72	73
Treated	0	187	187
Total	1	259	260

Source: own data, 2020.

found that one untreated milk producer was off support, while 72 untreated individual milk producers were on support. On other hand, 187 treated milk producers were found in the common support region. To sum up, only 1 individual milk producer was off support, while 259 milk producers were found to be on common support. Hence, based on the discussion here, it may be stated that this shows that the whole assumption of common support was not satisfied properly.

CONCLUSION AND RECOMMENDATIONS

Referring to the findings from the PSM to indicate the impact of Dairy Cooperatives on milk producers' Revenues of Ihuza Aborozi ba Kijyambere Bafatanyinje (IAKIB) in Gicumbi district, the study concluded that a dairy cooperative is a key marketing channel in which smallholder dairy producers could earn higher revenues, which thereafter satisfies daily needs. It is concluded that there is an increase in family ranging from 50,146 Rwandan francs (Rfs) to 168,145 Rwandan francs (Rfs) using nearest neighbour matching (NNM), kernel matching (KM) and radius matching (RM) for dairy cooperative members other than the control group. It was found that a dairy cooperative provides a better milk market channel because it offers a better market price compared to non-participants of dairy cooperatives.

It is therefore recommended to extend services to enhance farmers' access to dairy cooperatives (DCS) or other such institutions that can stimulate milk production in the state. Additionally, dairy cooperatives stand out from other milk marketing channels due to their involvement in the acquisition of milk and the provision of essential services to dairy producers. Dairy farmers that sell their milk to dairy cooperatives are paid fairly for it. Additionally, these facilities offer monetary security and periodically distribute funds to dairy farmers. As a result, the dairy cooperatives give the dairy producers a combined sum. The primary barrier to this channel is the dairy cooperatives' slow payment schedules. The impoverished households prefer to trade their marketable surplus through other channels, since they cannot wait longer to receive payment. Last but not least, in years to come, the diary cooperatives will have a significant impact on the economy of our country. The milk industry is expected to experience a new boom. The industry's significant impact in creating newer, direct and indirect employment opportunities, as well as its impact on raising the nutritional standards of our population, increase the sector's significance in the twenty-first century. Cooperatives can reach new heights in the near future with the right encouragement and member support. It is also recommended that the dairy cooperatives must consider a milk pricing policy that takes open market prices into consideration.

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