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How Does Cooperative Membership Affect Farm Efficiency? A Case Study of Dairy Farms in Izmir, Türkiye

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ABSTRACT

This study aims to measure the efficiency of dairy farms, both cooperative members and non-members, and to investigate the effect of farm size. To assess farm efficiency, we conducted Data Envelopment Analysis (DEA) and Tobit regression analysis to identify the factors that influence efficiency on farms. The study was carried out in Izmir, one of the most significant cities for dairy cooperatives and the dairy sector in Türkiye. The results showed that non-member dairy farms were more efficient than those of members. The study found that large-scale farms are more efficient than small-scale farms. It is also noteworthy that the majority of fully efficient small-scale farms are cooperative members. It can be concluded that cooperatives are more beneficial for small family farms in terms of efficiency; however, they have capacity limitations when compared to IOFs.

Keywords: Dairy farms, Data Envelopment Analysis, Tobit Regression, Efficiency, Agricultural Cooperatives

1. Introduction

The dairy industry plays a crucial role in agribusiness sector and ensuring food security in rural areas. The dairy processing sector is one of the largest subsectors of the EU's food processing industry. To sustain milk production, it is necessary to have a competitive and effective milk processing sector (Vlontzos & Theodoridis 2013; Zietek-Kwasniewska et al. 2022).

Türkiye is the eighth largest cow's milk producer in the world and third largest in the EU. The Turkish dairy industry has experienced substantial growth in export value, surging from over $167 million in 2009 to a noteworthy $371 million in 2020. This transformation has positioned Türkiye as a key supplier of dairy products in its region. Notably, this success can be attributed to the industry's strategic shift from a domestic market focus to a more internationally oriented approach (USK 2023).

Compared to crop production, dairy sector provides continuous farmer income covering the whole year. In Türkiye, farmers face numerous challenges in the process from production to marketing. These include small-scale farms, lack of financing, marketing issues, hygiene and quality concerns, high input prices, and inadequate use of information and technology. It is important to address these issues to improve the overall efficiency and profitability of the agricultural sector (Özüdoğru, 2010). Additionally, 40% of dairy farms in Türkiye consist of farms with 1-5 cows. Only 2.5% of farms have 50 or more cows. On average, each farm has approximately six dairy cows (MAF 2020). A comparison of EU countries to Türkiye revealed a notable difference in the yield of meat and milk. As reported by the FAO in the year 2022, Türkiye's yields in these two categories are considerably lower than the EU average (FAO 2022). In light of this, it is evident that the agricultural sector in Türkiye could benefit from the establishment of farmer cooperatives, which could serve to address the existing challenges faced by small family farms. Farmers' cooperatives play a crucial role in the vertical integration of dairy sector supply chains (Jansik et al. 2014). Their role is to bring smallholder farmers together and help them market their products collectively, negotiate better prices and access resources such as finance and technology. By promoting collaboration among farmers, cooperatives empower them with stronger bargaining power in the market, ensuring a fairer distribution of profits and reducing their vulnerability to price fluctuations. Cooperatives frequently offer training and support services to enhance the quality of dairy products, thereby improving the competitiveness of small-scale farmers in the industry (Inan et al. 2005). Given the conditions in Türkiye, the sustainability of dairy farms is at risk due to high input prices and low product prices. This is particularly the case for small-scale family farms, which constitutethe majority of the industry. Farmers gathered under the roof of cooperatives would be able to compete with their competitors both in production and product sales. Therefore, cooperatives are very important for the efficiency and sustainability of small-scale farms. In Türkiye, there are 11 754 agricultural cooperatives and 3 678 207 members. Agricultural cooperatives operate under three different laws*: Law No. 1163, Law No. 1581, and Law No. 4572, with a total membership of 3 678 207 (MAF 2024).

Based on this background, the main research question here is: *How does cooperative membership affect farm efficiency?* Although there are many studies conducted about determining the efficiency of dairy farms in Türkiye (Nizam & Armagan 2006; Koyunbenbe & Candemir 2006; Uzmay et al. 2009; Gul et al. 2018; Kaygisiz et al. 2018; Aydemir 2019; Güler & Saner 2020), however, a limited study has been conducted to compare the performance of member and non-member dairy farms. In this context, the aim of this study is twofold: (1) to assess the efficiency of dairy farms by comparing cooperative members and non-members, and (2) to estimate the factors that significantly impact the efficiency levels of these farms.

2. Literature Review

Several studies have been carried out on the efficiency of the dairy sector at the farm level in Türkiye and worldwide (Heshmati & Kumbhakar 1997; Reinhard et al. 2000; Jaforullah & Whiteman 2001; Helfand & Levine 2004; Nizam & Armagan 2006;Koyunbenbe & Candemir 2006; Candemir & Koyunbenbe, 2006; Hansson & Öhlmér 2008; Uzmay et al. 2009; Aldeseit 2013; Chagwiza et al. 2016; Gül et al. 2018; Kumar et al. 2018; Kaygisiz et al. 2018; Priscilla & Chauhan 2019; Güler & Saner 2020; Luiz Beber at al. 2021; Onyango et al. 2023). These studies suggest that implementing various strategies can enhance the efficiency of dairy farms (Heshmati & Kumbhakar, 1994; Fraser & Cordina 1999). If all farms operate at the efficiency levels observed in the top-performing farms, there is significant potential for substantial profits within the dairy industry. According to the study conducted on Finnish farms, it was found that the farms could reduce their costs by 31% if they were as technically efficient as the best farms in the sample (Oude Lansink et al. 2002). Güler & Saner (2020) studied sample of Turkish dairy farms, using data envelopment analysis (DEA), and they found that farm income can be maintained even if the inputs used in production are reduced by 11.6%, which means that profits can be increased. Another study conducted in Türkiye showed similar results, indicating that dairy farms can reduce inputs by 24.8% while maintaining the same level of output (Sert, 2019). Mitsopoulos et al. (2021) conducted a study in Greece using the DEA method to estimate the efficiency of dairy farms for both CRS and VRS approaches. The results showed that dairy farms can achieve a 30.7% and 21.6% equaproportional decrease in inputs given the level of outputs and the production technology. Reinhard et al. (2000) conducted a study on Dutch dairy farms and found an average technical efficiency score of 78% using the DEA method. Hansson & Öhlmer (2008) reported technical output efficiency ranging from 86% to 89% in a sample of Swedish farms.

There is a limited literature comparing the efficiency of dairy cooperatives and IOFs, as well as the efficiency of cooperative member and non-member dairy farms. Kumar et al. (2018) assessed the impacts of cooperative membership on welfare in Bihar, India. The impact of membership on farm performance was measured using some indicators such as milk yield, net returns, and adaptation of food safety measures (FSM). For the comparison of members and non-members, the Endogenous Switching Regression (ESM) model was used. The results indicated that dairy cooperative membership positively and significantly affected certain variables, such as income. In contrast, a study conducted in a different state of India by Priscilla & Chauhan (2019) used the propensity score matching (PMS) approach to determine the impact of cooperative membership on yield, price, income and technical efficiency. The findings indicated that there is no significant impact of dairy cooperatives on the economic well-being of their members. However, there is a positive and significant impact on employment, indicating a beneficial influence on society. Luiz Beber at al. (2021) conducted their study in Brazil, focused on the efficiency and productivity differences between cooperatives and IOFs in Brazil's institutional set-up. The study analysed 243 milk processors in southern Brazil and used production frontier to estimate technical efficiency. The results indicate that, in general, cooperatives are more efficient than IOFs. Zietek-Kwasniewskaet al. (2022) conducted a study in Poland comparing the technical efficiency of cooperative and non-cooperative dairies using the DEA method. They estimated technical efficiency under both constant returns to scale (CRS) and variable returns to scale (VRS). They found that dairy cooperatives were less efficient than non-cooperatives, which contrasts with the findings of Luiz Beber et al. (2021). The authors recommended that inefficient dairies reduce labor costs and depreciation.

Our previous knowledge suggests that farmer cooperatives have the potential to significantly increase the efficiency and productivity of farm level. This knowledge is supported by the research conducted by Abate et al. (2014) in Ethiopia. The researchers used propensity score matching approach to examine the technical efficiency of cooperative members and non-members. Their findings show that cooperatives are very efficient in providing support services that make significant improvements to the technical efficiency of their members. The study conducted in Kenya assessed the impact of cooperatives on smallholder dairy farmers' income. The scholars found that cooperative market participation increased farmers’ incomes by approximately 10% (Onyango, et al. 2023). Similarly, the study conducted in Ethiopia shows similar results as cooperative members' dairy income is higher than non-members (Chagwiza et al. 2016).

3. Material and Methods

* Under Law No. 1163, there are 9 780 cooperatives with 2 490 480 members.
Under Law No. 1581, there are 1 618 cooperatives with 853 869 members.
Under Law No. 4572, there are 338 cooperatives with 332 925 members.

3.1. Study area and data sources

The study was conducted in Izmir province, which is a significant city for dairy cooperatives and the dairy sector. The province is located in western Türkiye (Figure 1).

Figure 1- Research area

The region is distinguished by the prevalence of modern dairy farms and dairy processing industries, which are relatively uncommon in other agricultural regions of Türkiye. The production of cow milk in Türkiye has increased significantly in recent years, and the total rate of increase from 2004 to 2019 was approximately 116.24% (TurkStat 2023).

The majority of milk production is concentrated in the Aegean and Central Anatolia regions, although there are also dairy operations in other areas. The total milk production in Türkiye, the Aegean region, and Izmir was 20 782 374 tonnes, 3 751 147 tonnes, and 1 150 838 tonnes, respectively. Izmir has 30.68% of the milk production of the Aegean region and 5.54% of the milk production of Türkiye (TurkStat 2023).

Izmir is one of the most important provinces in Türkiye in terms of both dairy sector and dairy cooperatives competing with investor-owned firms (IOFs) in the market. There are significant cooperatives in the province that market products both locally and nationally under their own brands. Dairy cooperatives, in particular, are highly successful and powerful in this province's dairy industry. In Türkiye, a few successful dairy cooperatives dominate the majority of the market in Izmir. In Izmir, farmers often sell their raw milk to cooperatives or IOFs (dairy collectors, processors, etc.). Direct sales in streets or open bazaars are uncommon because food safety regulations state that such practices are prohibited (Notification No: 2017/20).

The selected province plays a significant role in agri-cooperatives, specifically in three types: agricultural development cooperatives, irrigation cooperatives, and fishery cooperatives. Currently, there are 163 agricultural development cooperatives with 19 641 members (Table 1).

Table 1- The number of cooperative members located in Izmir

	Number of cooperatives	*Number of members*
Agricultural development cooperatives (ADC)	163	19641
Irrigation cooperatives (IC)	82	13567
Fishery cooperatives (FC)	45	2519

Source: MAF 2020

Four well-known dairy cooperatives are involved in this study (Table 2). Because these cooperatives are vertically integrated and have their own processing facilities. Other dairy cooperatives in the region are just collecting milk from members and selling it to other cooperatives or investor-owned companies. The main aim of selected cooperatives is to help dairy farmers in the region develop both economically and socially while protecting both producers and consumers of their products.

Table 2- The number of members in selected cooperatives

	Number of members
Tire Milk ADC	1780
İğdeli ADC	2120
Bağarası-Yenibağarası ADC	170
Bademli Arboriculture ADC	275
Total	4345

Source: MAF 2020

The data for the empirical analysis was gathered from a sample of 200 dairy farms, which have cooperative members (100 dairy farms), and non-members (100 dairy farms). Member farms were randomly selected in cooperation with the selected cooperatives. Non-member farms were selected randomly from the same areas to ensure comparability. After identifying member farms, we asked for information about nearby non-member farms and conducted surveys with them. The sample size was determined by the proportional sampling method (95% for confidence interval and 10% for margin of error) (Newbold, 1995). The data was collected by using a structured questionnaire and personal interviews with the members and non-members during July-September 2021.

$$n = \frac{Np(1-p)}{(N-1)\sigma_{px^2} + p(1-p)} \tag{1}$$

Where: n, Sample size; N, The number of the dairy cooperative members in Izmir (Table 2); σ^2_{px},ratio variant

Dairy farms were divided into four groups according to the number of dairy cows, regardless of their membership status. While determining the distribution according to the scale of farms, the farms with five or more dairy cows were taken into consideration. While making the distribution of the groups, taking into account the studies conducted in the literature (Saner 1993; Talim et al. 1998; Armagan et al. 2004; Güler 2019; Sert 2019); dairy farms with 5-10 heads of cows formed group I, 11-25 heads formed group II, 26-50 heads formed group III, 51 heads and above formed group IV. The number and percentage of enterprises in each group are 64 (32.0%), 62 (31.0%), 43 (21.5%) and 31 (15.5%), respectively.

3.2. Data analysis

DEA, a nonparametric method of estimation, was used to measure the farm efficiency. DEA has been widely used in efficiency studies in the literature, including in the dairy sector (Jaforullah & Whiteman 2001; Heshmati & Kumbhakar 1997; Helfand & Levine 2004; Kumbar 2005; Nizam & Armagan 2006; Aldeseit 2013; Güler & Saner 2020; Von Hobe et al. 2021; Kaiser & Schaffer 2022). This method is based on comparing a group of homogeneous decision-making units (DMUs) with multiple inputs and outputs. In the method, which can be applied in cases where there are more than one input and output, the input and output combination is compared with others (Coelli 1995). DEA does not necessitate the specification of a specific functional form for the production frontier. This is important because specifying a functional form can potentially introduce bias into the results, as pointed out by Barnes (2006). The DEA method, originally proposed by Charnes et al. (1978), employs linear programming techniques to estimate the most efficient production frontier. In our present study, we chose to utilize this non-parametric DEA approach precisely because it eliminates the need for any prior specification of the functional form of the production function, thereby enhancing the robustness of our efficiency estimates.

This method, which is commonly used to establish efficient frontiers, uses linear programming methods to construct a nonparametric frontier. The efficient production frontier is constructed by utilizing all efficient and inefficient observations in the sample and the efficiency of each production unit is calculated according to this frontier. The frontier formed by efficient units also reveals the expected targets for other units (Günden & Miran 2001).

There are two methods used in Data Envelopment Analysis (DEA), namely CCR (Charnes, Cooper, Rhodes) and BCC (Banker, Charnes, Cooper).

The CCR Model, first proposed by Charnes et al. 1978, is a model based on the assumption of constant returns to scale and has a wide range of areas. This model, which is a radial model, is based on proportional changes in the levels of inputs or outputs, which means that an increase in its input levels leads to a proportional increase in its output levels. Therefore, the model is based on total factor productivity, which is the ratio of weighted total outputs to weighted total inputs (Cooper et al. 2000).

The representation of the constant returns to scale analysis is as follows (Charnes et al. 1978);

$$\begin{aligned} & \min \Phi,\lambda\theta, \\ \text{subject to.} \quad & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & \lambda \geq 0 \end{aligned}$$

The BCC DEA model is a model of variable returns of scale. Banker et al. 1984 first propose this model constructed by adding a convexity constraint to the constant returns to scale model.

θ is a scale and λ is a vector of N x 1 constants. By adding the convexity constraint N1' λ=1 to the linear programming problem, a variable return to scale model is formed;

$$
\begin{aligned}
& \min \Phi,\lambda\theta, \\
\text{subject to.} \quad & -y_i + Y\lambda \geq 0 \\
& \theta x_i - X\lambda \geq 0 \\
& N1'\lambda = 1 \\
& \lambda \geq 0
\end{aligned}
$$

Determining and understanding the factors that affect Technical Efficiency (TE) is critical for increasing efficiency and performance. Farrell (1957) defined TE in two ways: first, the ability of farms to produce the most feasible output with a given combination of inputs (output oriented); and second, the ability of farms to use the minimum inputs to produce a given level of outputs (input oriented). Input oriented models are used when there is little control over outputs. The aim of these models is to determine the extent to which the amount of inputs can be reduced proportionally without changing the current output. Output oriented models, on the other hand, seek to answer the question of how much output can be increased proportionally without any increase in the amount of inputs used.

We used both input oriented and output oriented models by considering the CCR model (Charnes et al. 1978) and BCC model (Banker et al. 1984). To conduct this, the DEAP Version 2.1 software of Coelli (1996) was used to measure the efficiency of dairy farms. A review of studies on the efficiency of dairy farms in the literature reveals that many of them employ only input-oriented models (Jaforullah & Whiteman 2001; Nizam & Armagan 2006; Gonçalves et al. 2008; Steeneveld et al. 2012; Gul et al. 2018; Lindsaar et al. 2019; Aydemir 2019; Güler & Saner 2020), while others use solely output-oriented models (Koyunbenbe & Candemir 2006; Theodoridis & Psychoudakis 2008; Uzmay et al. 2009; Huijps et al. 2010) and studies using both input and output oriented model together (Fraser & Cordina 1999; Kaygisiz et al. 2018; Sert 2019).

The input and output variables used in the efficiency analysis are given in Table 3. The model includes, as inputs, feed expenses, labour expenses (family and foreign labour), expenses of veterinary, medicine, vaccines and artificial insemination, other expenses (electricity, water, fuel oil, transportation, cleaning, etc.) and herd size (LSU) and the output was aggregated total annual animal production value (Table 3). We relied on previous research in the selection of the input variables (Kumbar 2005; Nizam & Armagan 2006; Gonçalves et al. 2008; Cabrera et al. 2010; Gelan & Muriithi 2012; Aldeseit 2013; Güler & Saner 2020; Koç & Uzmay 2022).

Table 3 presents descriptive statistics of output and inputs. The annual animal production value obtained by the farms varies between 82,982.00 TRY and 3,181,756.00 TRY, with an average of 655,229.88 TRY. Feed was the major expense on farms, at an average of 434,546.90 TL per farm. The average herd size is 43.00 LSU, with the largest farm having 191.00 LSU and the smallest farm having 3.90 LSU. When we examined the standard deviations of variables, it is remarked the sample heterogeneity and there is a large variation between the farms (Table 3).

Table 3- Summary statistics of variables used in the efficiency analysis

Output	*Mean*	*Std. Deviation*	*Min.*	*Max.*
Animal Production Value[a] (TRY)	655229.88	634038.50	82982.00	3181756.00
Inputs				
Feed expenses[b] (TRY)	434546.90	445042.30	41300.00	2345000.00
Labour expenses[c] (TRY)	44720.23	20935.82	10265.63	113562.50
Expenses of veterinary, medicine, vaccines and artificial insemination[d] (TRY)	13825.50	11638.86	2000.00	60000.00
Other expenses[e] (TRY)	29343.55	48703.82	2170.00	294500.00
Herd size[f] (LSU)	42.00	40.57	3.90	191.00

In 2021, 1 Euro was equal to an average of 10.47 TRY (Central Bank of the Republic of Türkiye, https://evds2.tcmb.gov.tr/index.php?/evds/serieMarket); [a],Total revenues of milk sales, livestock sales, carcass meat sales and fertilizer sales; [b], The sum of purchased and produced feed expenses; [c], The sum of the expenses of family and foreign labour; [d], The annual expenses of veterinary, medicine, vaccines and artificial insemination; [e], The sum of expenses such as electricity, water, fuel oil, transportation, cleaning etc; [f], Livestock Unit (LSU) is used in order to present the herd size of the farms examined homogeneously.

Tobit regression analysis was used to determine the factors of affect efficiency on farms. Instead of the classical ordinary least squares (OLS) method, the Tobit regression model was chosen since the scores of these factors vary between 0 and 1. The Tobit model is an extension of the Probit model developed by James Tobin. This model, in which the dependent variable is treated as limited, is also called censored (discrete) regression model (Gujarati 2004). The data set can be censored from top to bottom or within a certain range. The standard Tobit model equation can be showed as follows: (Ramanathan 1998).

$$u_i > -\beta_0 - \sum_{i=1}^{N} \beta_i X_i \qquad if \qquad Y_{ij} = \beta_0 + \sum_{i=1}^{N} \beta_i X_i + u_i \tag{2}$$

$$u_i \leq -\beta_0 - \sum_{i=1}^{N} \beta_i X_i \qquad if \qquad Y_{ij} = 0 \tag{3}$$

Where: Y_{ij}, dependent variable for i. farm; X_i, independent variables affecting the dependent variable; N, number of dependent variables; β, model parameter; u, error term.

The Tobit regression analysis was executed under the results of BCC DEA model. Thus, the Tobit model allows us to comment on the effects of the independent variables used in the model on the output-oriented efficiency of the farms. We used GRETL to perform tobit regression analysis for factors affecting the efficiency of farms. Efficiency values are censored between 0-1 in the tobit model.

We chose seven independent variables related to farms and farmers characteristics for tobit analyses. These are composed of years of farmer's age (AGE), years of farmer's education (EDUCATION), household size which means that number of family members (HSIZE), number of agricultural organizations that it is a member of (AGRORGANIZATION), provided agronomic services by firms (which by cooperatives or IOFs) (AGRONOMICSERVICES), having milk cooling tank (MCTANK) and whether to become a member of the cooperative (members sell milk to cooperatives, nonmembers sell milk to IOFs) (COOPMEMBERSHIP).

Multicollinearity among the independent variables was checked using the Variance Inflation Factor (VIF) test. It was shown that there is no multicollinearity problem, and the highest value is 4.79 which has COOPMEMBERSHIP variable.

4. Results and Discussion

4.1. Efficiency analysis

The efficiency scores of dairy farms were estimated both input-oriented and output-oriented models by considering the CCR and BCC model depicted in Table 4. As indicated in Table 4, in CCR model, input-oriented and output-oriented efficiency values are the same, whilst there is a slight difference in BCC model (Table 4).

Table 4- Distribution of efficiency scores of dairy farms (%)

Efficiency Score	*CCR Model*		*BCC Model*	
	Input oriented	*Output oriented*	*Input oriented*	*Output oriented*
1	26.50	26.50	38.00	37.50
0.999 - 0.901	14.00	14.00	21.00	15.00
0.900 – 0.801	18.00	18.00	15.00	16.50
0.800 – 0.701	17.00	17.00	17.50	15.50
0.700 – 0.601	14.50	14.50	6.50	9.00
< 0.600	10.00	10.00	2.00	6.50
Mean	0.832	0.832	0.894	0.874
Std. Deviation	0.155	0.155	0.121	0.141
Min.	0.527	0.527	0.529	0.537
Max.	1.000	1.000	1.000	1.000

When we examined the CCR model efficiency scores, the lowest efficiency score is 0.527, the highest is 1.000 and the mean is 0.832. When this situation is thought according to the input-oriented model, it shows that farms can obtain the same animal production value with 16.8% less inputs, and according to the output-oriented model, they can increase their animal production value by 16.8% provided that the inputs remain the same. 26.5% of farms are fully efficient in terms of the CCR model and 38% of farms are fully efficient under the BCC model. The input oriented scores estimated under the BCC model are higher than those calculated as output oriented under the BCC DEA model. In terms of the BCC model, the input oriented efficiency score was estimated at 0.894 and the output oriented efficiency score at 0.874 (Table 4).

Other studies, which were conducted in Aegean region, reported similar results to ours (Koyunbenbe & Candemir 2006; Nizam & Armagan 2006; Sert 2019; Güler & Saner 2020). In studies conducted in other regions of Türkiye reported less mean technical efficiency scores (Kumbar 2005; Aydemir 2019; Güneş & Güldal 2019). A review of studies conducted outside Türkiye reveals that the efficiency scores of dairy farms vary. The efficiency score was estimated as 94% in New Zealand (Jaforullah & Whiteman 2001), 78% in the Netherlands (Reinhard et al. 2002), 87% in the UK (Gerber & Franks 2001), 63% in Greece (Theodoridis & Psychoudakis, 2008), 79% in Austria and 78% in Ireland (Kelly et al. 2012). The study conducted in a sheep farm in Spain showed that the efficiency of low-technology farms was 70%, while that of high-technology farms was 83% (Morantes et al. 2022).

Summary of dairy farm efficiency scores according to marketing channels is contained in Table 5. The technical efficiency scores estimated under the CCR are equal both input and output-oriented models. It was depicted the CCR model, the efficiency score of dairy farms selling milk to cooperatives is 0.781 with a standard deviation of 0.165. The efficiency score of dairy farms selling milk to IOFs is 0.882 with a standard deviation of 0.126. The technical efficiency scores were calculated to be higher in the BCC model than predicted by the CCR model. Furthermore, both cooperatives and IOFs perform better under input-oriented than output-oriented conditions (Table 5).

Table 5- Summary of efficiency scores of dairy farms by marketing channels (Coop.-IOFs)

		Cooperative		*IOFs*	
		Mean	*Std. Deviation*	*Mean*	*Std. Deviation*
CCR Model	Input oriented	0.781	0.165	0.882	0.126
	Output oriented	0.781	0.165	0.882	0.126
BCC Model	Input oriented	0.883	0.128	0.905	0.113
	Output oriented	0.843	0.158	0.904	0.113

As indicated in Table 6, the CCR and BCC model results for dairy farms, classified into four groups based on scale size, are presented. When the efficiency scores are estimated under the CCR model, it is seen that the largest farms have the highest efficiency scores, while the smallest have the lowest. According to the BCC model, the farms with the highest efficiency scores for both input and output are the largest farms (Group IV).

Table 6- Summary statistics of dairy farms according to scale

		Scale of farms				
		I.Group (64) 5-10 heads	*II.Group (62) 11-25 heads*	*III.Group (43) 26-50 heads*	*IV.Group (31) ≥51 heads*	*p-value*
CCR Model	Input oriented	0.762	0.853	0.847	0.911	<0.001*
	Output oriented	0.762	0.853	0.847	0.911	<0.001*
BCC Model	Input oriented	0.903	0.891	0.859	0.928	0.003**
	Output oriented	0.855	0.872	0.852	0.945	0.003**

*: significant for p≤0.001; **: significant for p≤0.05

As shown in Figure 2, scatter of efficiency score of dairy farms according to scale is different to CCR models and BCC models. When the fully efficient farms are examined according to scale, 54.8% of the farms in Group IV are fully efficient, while the ratios of the farms in Group I, Group II, and Group III are 25.00%, 25.80%, and 11.60%, respectively.

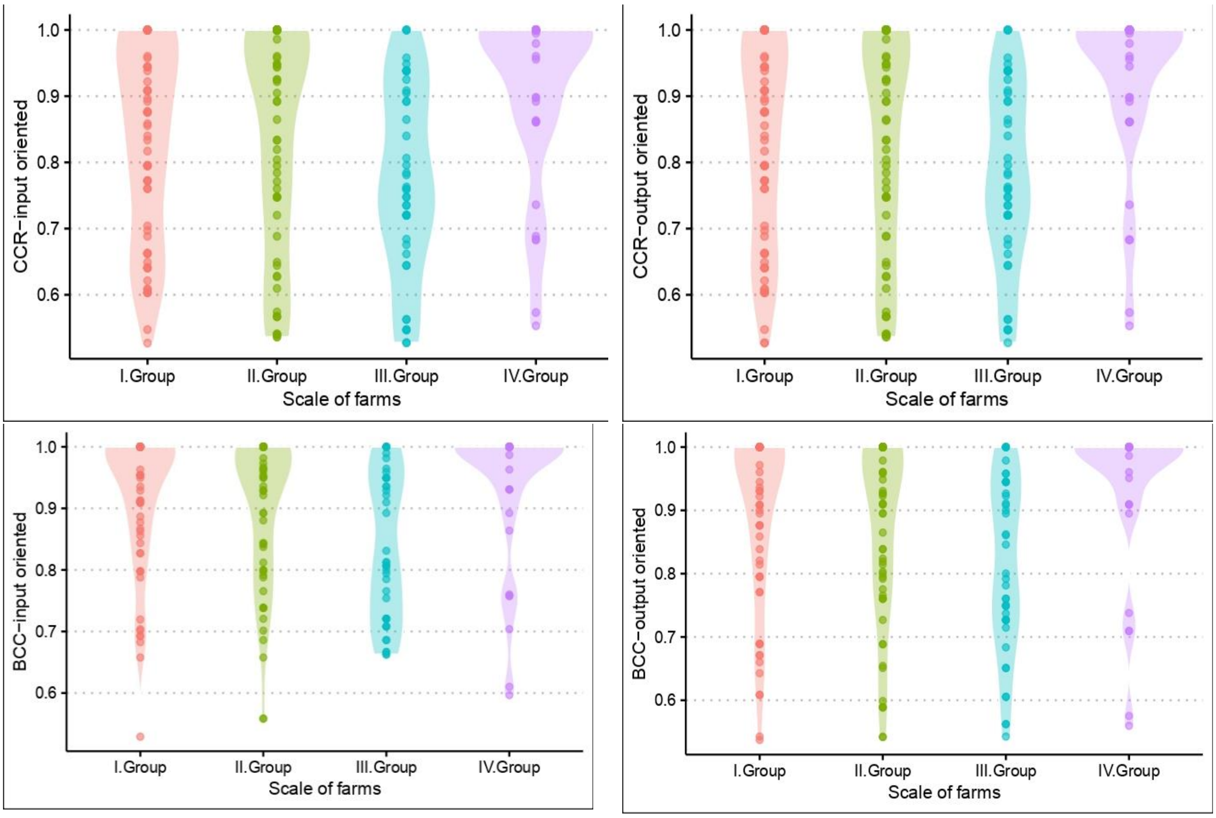

Figure 2- The scatter of efficiency scores of dairy farms according to scale

Figure 3 presents the distribution of fully efficient farms by scale and marketing channels. In comparison to non-member small-scale farms, small-scale member farms (Group I) are more prevalent among fully efficient farms under both the BCC and CCR models. In other words, cooperatives have a higher proportion of fully efficient small-scale farms compared to non-member alternatives. This indicates that cooperatives are better suited for small-scale farms and highlights the critical role of cooperatives in supporting small-scale farms compared to non-member alternatives.

In the study, a potential improvement analysis was conducted for dairy farms. With the potential improvement analysis, potential improvement ratios were determined according to the input target values for how inefficient farms can become efficient by using the combination of inputs and outputs of efficient farms in their reference cluster. When the potential improvement rates in the input-oriented model are examined, in order to achieve full efficiency in farms without much change in output; labor expenses should be reduced by 12.40%, other expenses (electricity, water, fuel oil, transportation, cleaning, etc.) by 13.44%, herd size (LSU) by 13.96%, feed expenses by 14.91%, and expenses of veterinary, medicine, vaccines, and artificial insemination by 15.64%. In terms of an output-oriented model, the value of animal production should be increased by 18.07% in order for the farms to achieve full efficiency. Upon examining the findings of both member and non-member dairy farms, it was determined that the members should aim to increase the value of animal production by 14.26%, whereas the nonmembers should aim for an increase of 11.42%.

We analysed constant returns to scale (CRS), decreasing returns to scale (DRS) and increasing returns to scale (IRS). CRS means that a proportional increase in the level of input occurs at the same rate at the output level. VRS means that a proportional increase in the level of inputs occurs at a different rate at the level of output. If the increase in output is greater than the proportional increase in all inputs, we have increasing returns to scale, and if it is less, we have decreasing returns to scale.

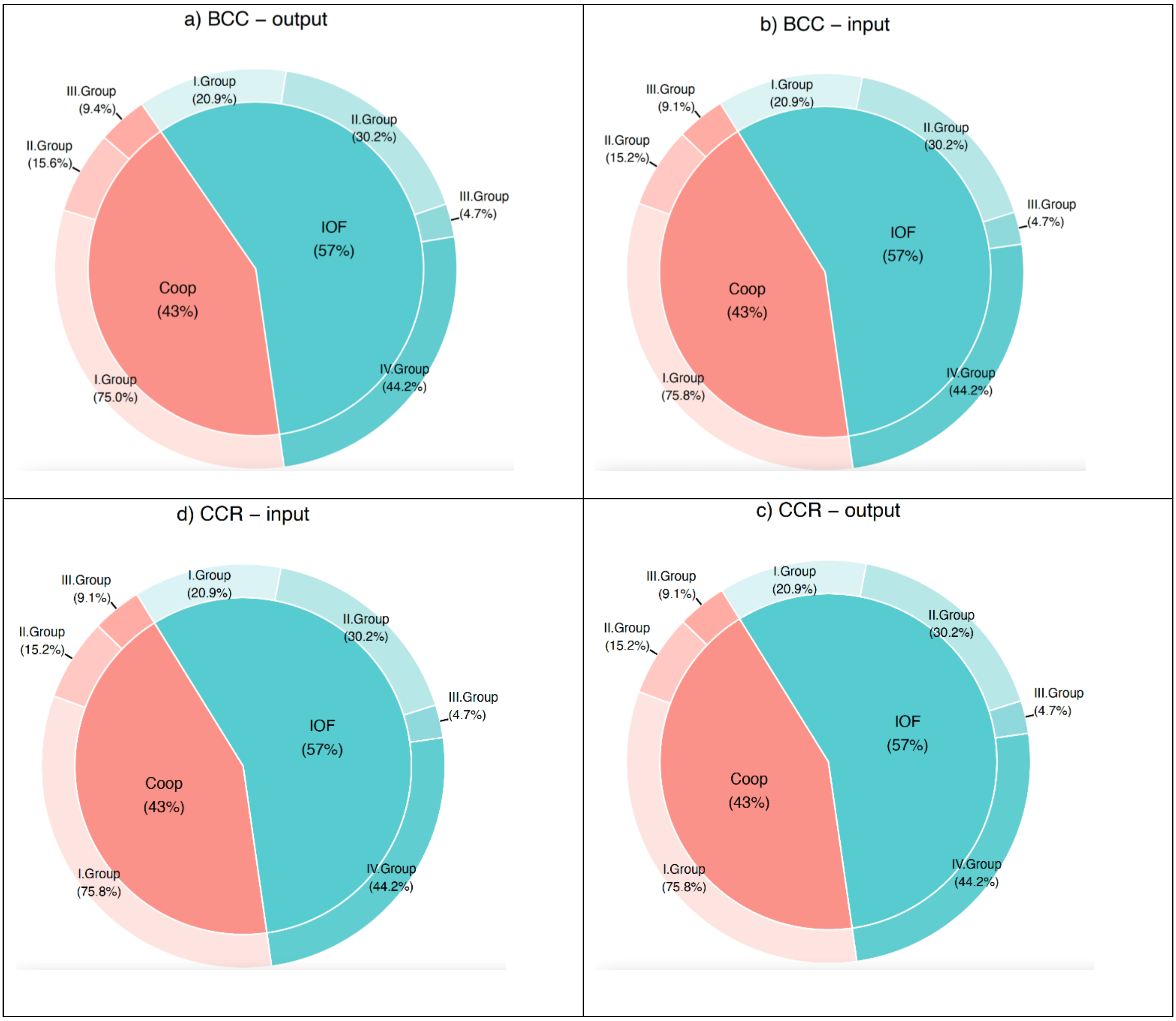

Figure 3- Distribution of fully efficient farms by scale and marketing channels (Coop – IOFs)

The results show that according to the input oriented model, 62.0% of farms (124 dairy farms) operate under increasing returns to scale. Of these 124 farms, 44 of the farms sell milk to IOFs and 80 of the farms to cooperatives. This is an expected result since the farms selling milk to cooperatives are smaller than the others. In terms of an output-oriented model, the results are similar. 50.5% of farms (101 dairy farms) operate under increasing returns to scale. In addition, these 69 farms sell milk to cooperatives and others sell to IOFs. As a result, they should be able to increase their efficiency by expanding.

In the study conducted in Izmir province, the scale efficiency of dairy farms was analyzed according to both input and output-oriented models. In the input and output-oriented model, 60% of the farms and 48% of them were found to have increasing returns to scale, respectively (Sert 2019). In another study conducted in the Thrace region, 82.3% of dairy farms were found to have increasing returns to scale (Kumbar 2005). According to Jaforullah & Whiteman (2001), 53% of farms in New Zealand and, according to Angon et al. (2021), 80% of farms in Argentina operate on an increasing returns scale.

4.2. Factors affecting efficiency of farms: Tobit analysis

Tobit estimates were analysed for efficiency measures (BCC output-oriented model) using 200 observations. The results of Tobit regression analysis are presented in Table 7. Most of the independent selected variables have significant effect on the efficiency measures. Among seven variables used in this study, only EDUCATION has not impact on the efficiencies, AGE and COOPMEMBERSHIP have a negative impact and others have a positive impact on the efficiencies.

Table 7- Tobit regression results

	Marginal Effect	*Coefficient*	*Std. Error*	*z-statistic*	*p-value*
Constant	-------	0.6667	0.0757	8.8021	<0.0001*
AGE	-0.0553	−0.0688	0.0186	−3.7057	0.0002*
EDUCATION	0.0018	0.0022	0.0034	0.6615	0.5083
HSIZE	0.0191	0.0238	0.0075	3.1699	0.0015*
MCTANK	0.0820	0.1020	0.0286	3.5670	0.0004*
COOPMEMBERSHIP	-0.1609	−0.2001	0.0574	−3.4853	0.0005*
AGRONOMICSERVICE	0.0466	0.0580	0.0137	4.2163	<0.0001*
AGRORGANIZATION	0.0290	0.0360	0.0117	3.0789	0.0021**
Log-likelihood 15.3980 Test statistic: Chi-square(2) = 10.8784 with p-value = 0.0043					

*: significant for $p \leq 0.001$; **: significant for $p \leq 0.01$

Younger farmers are better educated and more cautious than older farmers. As expected, AGE has a statistically significant negative impact on technical efficiency, so a one-year increase in a farmer's age results in a 5.53% decrease in farm efficiency. Despite the fact that EDUCATION was not found to be statistically significant, its impact on farm efficiency is positive. The results suggest that an increase in the size of household by one person would lead to an increase in the efficiency of farms by 1.91%. Family labor is used intensively in dairy farms, so number of family members is an important factor in the efficiency of farms. Koç (2022) found similar results in a study conducted in the Thrace region of Türkiye: technical efficiency in dairy farms was negatively affected by age, positively affected by education.

The presence of milk cooling tank (MCTANK) in the farms has a positive and significant effect on the efficiency of farms. When compared to farms without one, having a milk cooling tank increases farm efficiency by 8.19%. Cooling tanks in dairy farms have an effect on both sales price and quality. There is a big difference in quality between the milk that reaches the cooling tank untouched and waits in the cooling tank until it reaches the buyer and the milk that is milked in barn conditions where milking hygiene is not paid enough attention and waits in unsuitable conditions for a long time until it reaches the buyer. There is also a difference between the sale prices of this milk. In other words, the presence of a cooling tank in farms (selling cold milk) is an important factor affecting the efficiency of farms. In addition, this situation shows that technology adaptation is higher in farms. This can be associated with technology. In this case, it would be appropriate to say that the use of technology increases efficiency.

COOPMEMBERSHIP has a statistically significant negative impact on efficiency of farms. Non-member farms sell milk to IOFs while member farms sell to cooperatives. The results showed that non-member farms were more efficient than member farms. This is related to size of farms, because nonmember farms are larger than member farms. However, when the small-scale and efficient farms are assessed, it is noted that member farms are quite high. In this case, it is possible to say that co-operatives are more suitable for small-scale farms and contribute positively to the efficiency of these farms. As was expected, AGRONOMICSERVICE has a statistically significant positive impact on efficiency. We know that cooperatives provide more agronomic services for members, so this increases the efficiency. AGRORGANIZATION has a statistically significant positive impact; farms with more agricultural organization memberships are more efficiency than farms with fewer memberships. This result agrees with the works of Kumbar (2005) in Thrace region, Türkiye.

5. Conclusions

An analysis of the efficiency results of dairy farms revealed that non-member farms were more efficient than member farms. According to scale of farms, it was determined that the efficiency of large-scale farms was higher. In addition, it is noteworthy that the majority of small-scale and efficient farms are cooperative members. This suggests that cooperatives are necessary, particularly for small-scale farms, and that they should be organizations dedicated to the sustainability of small farms. When the return to scale analysis was analyzed, as can be seen, the members' farms operate with increasing returns to scale. This means that the increase in output is greater than the increase in inputs. In general, it is recommended that the farms should reduce the expenses of veterinary, medicine, vaccines, and artificial insemination more than other inputs. Dairy farms of members need more improvements than others. At this point, it is important that members use the services provided by cooperatives effectively. For feed expenses, one of the most important expenses, cooperatives should not sell feed at higher prices to members who are already in debt. This situation forces members to work as debtors.

When the factors affecting the efficiency of farms were analyzed, it was observed that younger people worked more effectively than elders. It is believed that factors such as young people having greater awareness, adopting innovations, and planning for the future play a significant role. The presence of a cooling tank, which can be characterized as the use of technology, is a factor that increases efficiency in farms. The higher price of cold milk and the improved quality and hygiene of milk obtained through automatic milking systems are factors that enhance efficiency. Although non-member farms exhibit higher overall efficiency, most efficient small-scale farms are cooperative members. This suggests that cooperatives contribute to improving the efficiency of small-scale farms. Additionally, cooperatives offer more agronomic services to their members. This has a positive effect on efficiency of farms. Membership in agricultural organizations is another factor that enhances efficiency. In addition to cooperatives, membership in producer unions and benefiting from the services of these organizations would increase the efficiency of farms.

This study concludes that cooperatives are better for small family farms; however, they have capacity issues when compared to IOFs. To increase their capacity and reach more farmers, cooperatives require support from municipalities and governments. Policymakers should consider providing assistance to cooperatives for their expansion, contributing to the sustainability of small-scale farms. In Türkiye conditions, there is a need for financial assistance to explore avenues for cooperatives to offer competitive prices on inputs and prevent members from working in debt. Cooperative managers should avoid showing opportunistic behavior and instead prioritise cooperative management in governance, avoiding self-interest and deception. In this context, it is necessary to implement training programs for cooperative management to ensure effective governance and prevent opportunistic behavior. If the main factors that distinguish cooperatives from IOFs are ignored, there will be no benefit to farmers from cooperatives. Small-scale farms will be condemned to closure and the sector will be monopolised under the management of large enterprises.

While this study contributes to the literature on the efficiency of dairy farms by comparing cooperative members and non-members, it is important to acknowledge certain limitations. Firstly, the research focuses on a specific region within Türkiye, which may limit the generalizability of the findings to the whole Turkish dairy industry. Future studies should address these limitations by expanding the geographical scope and incorporating a more comprehensive set of variables. Furthermore, different techniques can be used with different variables. Taking these limitations into account will contribute to the development of more robust and comprehensive insights in subsequent studies.

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