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TECHNICAL EFFICIENCY OF DAIRY CATTLE FARMS IN EAST MEDITERRANEAN REGION OF TURKEY

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Abstract

This study aimed to determine the efficiency level of dairy cattle farms in provinces of East Mediterranean Region in Turkey. The data were gathered by questionnaire from 148 dairy farms in the areas of Adana, Osmaniye, Mersin, Hatay and Kahramanmaraş. Data envelopment analysis (DEA) method was used to calculate efficiency scores. Our analysis carried out in two steps. Firstly, technical efficiency scores were computed employing an input-oriented DEA. Technical efficiency value was amounted to be 78%. In the second phase, the relationship between the value of defined socio-economic variables and the value of obtained technical efficiency scores were calculated by the Tobit regression analysis. The annual milk production per cow was used in the study as the dependent variable. Concentrates, roughage, health expenditures, other variable expenditures, workforce and capital expenditures were considered per cow as independent variables. 5% statistically meaningful and positive relationship was determined by the value of technical efficiencies and rate of the family labour and herd size. It was decided that artificial insemination and farmer's age had a negative effect on the efficiency and it was at a 10% level, statistically meaningful.

Key words: *efficiency, dairy cattle farm, data envelopment analysis, Tobit regression analysis*

INTRODUCTION

The animal husbandry sector plays an essential role in the agricultural development of all countries [81]. Animal husbandry is vital for Turkey regarding both social and economic aspects. Turkey has the right natural resources and ecological conditions in that regard. In addition to the decline in animal numbers, support for animal husbandry has also changed in recent years. Along with these, Turkey's animal husbandry sector still suffers continuing structural, economic, and technical issues. The volatility of government policies and market structure have restricted the growth of the industry, resulting in a decrease in the number of animals and volatility in product prices, which has affected the consumption of animal products.

As of 2016, the cattle population in Turkey was 14 million head. About 46.79% of total cattle population was culture breeds, 40.90% crossbreeds and 12.31% native breeds [77].

In the world, the dairy cattle have the most significant share in all milk-producing animals. In Turkey, the number of dairy livestock differs widely from that of the world.

As of 2016, the total amount of milk production in Turkey was 18,489,161 tons. About 16,786,263 tons (90.79%) of this milk was obtained from dairy cattle. The amount of sheep milk production, which has a significant share in the total number of dairy animals, remains very low [77].

Among the most critical subsectors in animal husbandry, are dairy cattle breeding and fattening cattle breeding. Of these two production lines, the development of fattening cattle industry may depend on dairy cattle breeding, since dairy cattle breeding is a sector associated with beef cattle. Positive events in dairy cattle directly affect the fattening animals and the meat market because the primary material of fattening cattle is obtained from dairy cattle sector. In that sense, it is possible to consider dairy cattle as the essential production area. The studies supporting dairy cattle also improve the condition of fattening cattle breeding, thus helping to develop the country's animal husbandry sector as a whole.

The research area was Eastern Mediterranean Region, which includes the provinces of Adana, Osmaniye, Mersin, Hatay and Kahramanmaraş. The cattle population in this region accounted for 5.29% of Turkey's total cattle population in 1991, but this share declined to 4.86% in 2016. The cattle population in the area has shown a sharp fall since 1991, and by 2003, the cattle presence had decreased by 27% as compared to 1991. From that year, the cattle population tended to increase again. In 2016, cattle population raised to 684,717 head (Fig. 1).

Like all cattle breeds in Turkey, the structure of cattle breeds in the Eastern Mediterranean region showed a variation in the period examined. In 1991, 10.18% of the cattle in the area consisted of culture breeds, 43.46% crossbreeds, and 46.36% native breeds. The distribution of livestock breeds continuously changed in the period, and in 2016, 42.29% of the cattle were culture breeds, 51.44% crossbreeds and 6.27% native breeds (Fig. 2).

The region supplied 8.34% of total cattle milk production in 1991. However, in 2016 this value fell to 5.5%. Thus, although both cattle milk productivity and carcass weight increased in the region, its share in Turkey showed a decline.

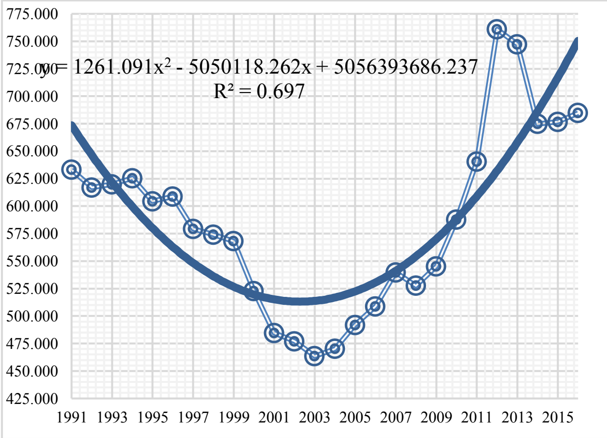

Fig. 1. Changes in cattle number in the research area
Source: TUİK [77].

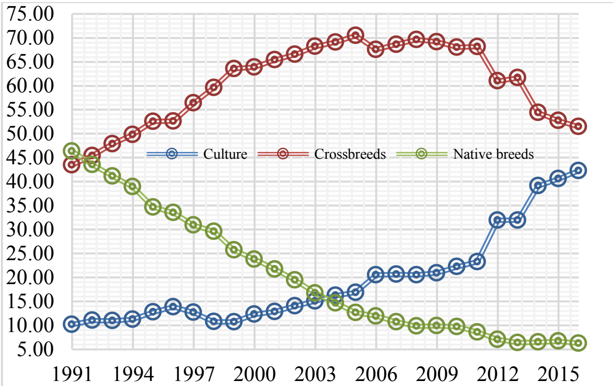

Fig. 2. Changes in cattle breeds in the research area
Source: TUİK [77].

That point of view, the efficiency of dairy cattle breeding in the region should be addressed.

The primary methods used to measure the efficiency of production units can be divided into two groups: parametric and nonparametric methods. In both ways, the principal is to obtain a production limit and to measure the efficiency of the production units against this limit. The production limit created represents the maximum output that can be achieved under a given technology. The production limit by parametric methods is determined econometrically. In the nonparametric techniques, a partial linear production limit is obtained by using the observed data, and there is no need for assuming any functional form for the production limit[9][41][21] [32][33][35][34].

There are some studies based on efficiency measurements in dairy cattle farms in Turkey. Binici et al. [11] in Burdur province, Koyubenbe and Özden [49] in İzmir, Gündüz [38] in Samsun, Alemdar et al. [3] in Adana, determined dairy farms' efficiency scores by parametric methods.

Koyubenbe and Candemir [48], Günden et al. [37], Uzmay et al. [78] in İzmir, Ceyhan and Hazneci [18], Özüdoğru [63] in Amasya, Demircan et al. [26] in Burdur, Dagistan et al. [25], Yılmaz [80] in Adana, Armağan and Nizam [6], Özden [60] in Aydın, Oğuz and Canan [58] in Konya, Parlakay et al. [64] in Hatay, and Terin et al. [76] in Kirklareli, calculated the efficiency scores of dairy cattle farms by non-parametric methods. Özden and Armagan [61] in Aydın and Gözener [31] in TR 83 region (Amasya, Çorum, Samsun, and Tokat provinces), determined efficiency score both methods.

There are numerous international studies conducting efficiency measurements in dairy farms. For examples; Sharma et al. [71] computed the farms’ technical, allocative and economic efficiencies in swine production by using parametric and nonparametric models and discovered 0.759, 0.758 and 0.571 respectively, with the parametric models and 0.759, 0.803 and 0.603 with DEA. Ahmad and Bravo-Ureta [2] found 0.76, 0.77, and 0.86 of Vermont dairy farms’ technical efficiency scores with using different parametric models for the 1971-1984 period. Kumbhakar et al. [45] used three parametric functions to compute dairy farms’ technical and allocative efficiency in the US. Stokes et al. [72] determined efficiency score of dairy producers with the DEA in Pennsylvania and found that 29% of total farms were efficient. Tauer [73] calculated cost efficiency of a dairy farm in New York and claimed that the productive small-scale dairy farm could compete with the efficient large-scale farm. Tauer and Belbase [74] determined the dairy farms’ technical efficiency scores by using parametric methods in New York by using the parametric method and calculated that 69% of them were efficient. Nehring et al. [56] determined the efficiency scores of small US dairy farms by using parametric functions. Bravo- Ureta [12] calculated technical efficiency scores with the 0.8217 as the range between 0.5769-1.00 for dairy farms with the probabilistic frontier function model in New England. Bravo-Ureta and Rieger [13] used stochastic frontiers to determine dairy farm efficiency and found as 0.70 in New England. Featherstone et al. [28] calculated technical, allocative and scale efficiency scores as 0.78, 0.81, and 0.95 respectively with a nonparametric method for beef cow farms in Kansas. Cabrera et al. [16] found technical efficiency as 0.88 of a dairy farm in Wisconsin by stochastic frontier model. Also, Curtis et al. [24] calculated this score as more than 0.90 for dairy farms in Wisconsin with same methods.

Theodoridis and Psychoudakis [75] used stochastic frontier and DEA methods to calculate the dairy farms’ technical efficiency values in Greece and found 0.8121 with stochastic frontier and 0.6849 with DEA. Latruffe et al. [52] determined the technical efficiency scores and measured the impacts of the subsidies on efficiency scores in European dairy farms by using the stochastic production frontier model, Madau et al. [53] calculated the technical efficiency and total factor productivity changes in European dairy farm with DEA. Abdulai and Tietje [1] computed dairy farms’ technical efficiency with stochastic frontier models in northern Germany and found technical efficiency score as 0.89 to 0.945 with different models over 1997–2005. Brümmer et al. [14] determined dairy farms’ technical efficiency by using parametric model and found as 0.879 in Germany, 0.904 in the Netherlands, and 0.853 in Poland. Brümmer and Loy [15] calculated technical efficiency as 0.96 of a dairy farm in Northern Germany with the stochastic frontier model. Barnes [8] calculated efficiency scores for the Scottish dairy as 0.841 by using DEA. Kleinhanß et al. [44] used DEA to estimate economic efficiency for animal farming in Spain and Germany. Reinhard et al. [67] calculated technical and environmental efficiency of Dutch dairy farms by using parametric functions. Zhu et al. [82] determined differentials of the dairy farms’ technical efficiency and productivity in

German, Dutch and Swedish and measured the role of CAP subsidies on the scores. Latruffe et al. [51] used stochastic frontier and DEA model to calculate the crop and livestock farms' technical efficiency in Poland and found 0.88 with the stochastic frontier method and 0.71 with DEA for livestock farms. Hallam et al. [40] used three parametric methods to determine efficiency score and found as 0.64, 0.74 and 0.88 for dairy farms in Portugal. Hansen et al. [41] calculated economic efficiency as near 0.60 of dairy farms by using DEA in Norway. Hansson and Öhlmer [42] calculated economic, technical and allocative efficiency by DEA and found as 0.616, 0.889, and 0.692 in short run and 0.645, 0.865, and 0.752 in long run of dairy farms in Sweden. Johansson [43] determined the technical, allocative and economic efficiency of dairy farms in Sweden by using DEA and stochastic frontier model and found 0.55, 0.75, and 0.41 by stochastic frontier and 0.74, 0.61, and 0.45 by DEA respectively. Põldaru and Roots [66] estimated economic efficiency of milk production in Estonia by using parametric models and found milk cost would be reduced as 0.80 cents of dairy farmers. Bezlepkina et al. [10] researched subsidies affecting on allocative efficiency for Russian dairy farming. They used DEA analysis to calculate the these farms' technical and allocative efficiency.

Mor and Sharma [54] and Saha and Jain [68] determined as 0.66, 0.79 [54], and 0.911[68] of the technical efficiency in dairy farms in India by using parametric functions. Moreira López et al. [55] found range 0.672 to 0.884 of technical efficiency score for dairy farms in Argentina by using stochastic production models. Paul et al. [65] calculated efficiency in New Zealand sheep and beef farming by using parametric functions and measured the impacts of regulatory reform on efficiency scores. Wei [79] calculated efficiency scores of New Zealand dairy farms as 0.96, 0.82 and 0.86 by using parametric and nonparametric methods. Fraser and Cordina [29] used DEA to calculate efficiency score as 0.905 and 0.908 with input oriented, 0.89 with output oriented, for dairy farms in Australia. Kompas and Che [47] used two parametric functions to estimate the dairy farms' technical and economic efficiency in Australia and found as 0.87. Gelan and Muriithi [30] measured technical efficiency scores with DEA of dairy farms as 0.488 in East Africa. Lachaal et al. [50] also used DEA to estimate technical efficiency in Tunisia and determined that 47% of the dairy farms produce below 80% of their potential.

Therefore this study aimed to examine the dairy cattle farms' technical efficiency in the Eastern Mediterranean Region and detect the factors causing inefficiency in production.

MATERIALS AND METHODS

The data were obtained through a questionnaire administered by face-to-face interviews in the farms engaged in dairy cattle breeding in the provinces of Adana, Osmaniye, Mersin, Hatay and Kahramanmaraş in the Eastern Mediterranean Region [81].

A list of agricultural farms engaged in dairy cattle breeding was retrieved from the TURKVET registration system in 20 villages determined by purposive sampling. The record revealed that there were 2,559 enterprises involved in dairy cattle farming. Since the variation was high regarding the number of dairy cattle, we chose to use stratified sampling method. After testing of the various alternatives, the enterprises were classified into four groups: farms with 1-2 head, those with 3-8, those with 9-28 and those with 29 head and more dairy cattle. The study sample size was determined within 5% error and 95% confidence limits. By the "Neyman Method", one of the stratified sampling methods the sample volume was calculated [20]. Accordingly, a total of 148 farmers have interviewed: 10 farms for the layer I, 44 for the segment II, 75 for the section III and 19 for the layer IV.

In the study, DEA method was used for nonparametric techniques which are widely used in measuring the technical activities of dairy cattle farms. The efficiency measurement employs the boundary approach, assuming that observations with the best performance are on the efficient boundary.

Nonparametric methods involve multiple independent input and output models, but they are reduced to a single efficiency measure, allowing each dimension to be measured at the same time.

DEA was first introduced with the work of Farrell [27] and became more popular after the study by Charnes et al. [19]; various researchers in various fields now use it.

DEA can be examined with the Constant Returns to Scale (CRS), and Variable Returns to Scale (VRS) approaches. Charnes et al. [19] proposed a model that suggested an intrinsic and constant return to scale (CRS) approach. In the literature, this method is referred to as CRS or the CCR model, representing the initials of the authors. Since the CRS is valid only when all decision-making units operate at the optimal scale [23], Banker et al. [7] presented the approach of VRS. Banker et al. [7]'s model is referred to in the literature as VRS or as BCC to represent the initials of the authors. They introduced the VRS approach by adding only the convexity constant ($N1\lambda = 1$) to the equation used in the CRS approach [23].

$\text{Min}_{\theta,\lambda}\ \theta$,

Under the following constraints;

subject to $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$N1'\lambda = 1$,

$\lambda \geq 0$,

Here, θ is a vector of scalar and λ N × 1 constants. The value of θ indicates the efficiency value of the *i*th enterprise. The result is $\theta \leq 1$, and one means efficiency [27]. N1 is a vector consisting of value 1 with a dimension Nx1.

Scale efficiency reveals the losses due to failure to produce at an optimal level. If a production unit's production scale is optimal, increasing or decreasing the production scale will reduce efficiency [36]. The scale efficiency (SE) can be explained by the following formula, taking advantage of the difference between the technical efficiency (TE) scores acquired with CRS and VRS[23]:

$TE_{CRS} = TE_{VRS} \times SE$

In this study, the resultant efficiency values calculated by the DEA were obtained as input-oriented on the assumption of CRS and VRS. All explications supposed that the producers in the dairy farms were operating under similar conditions.

A large number of computer software has been developed to perform efficiency analyses. In this study, DEAP was used for DEA, and EViews software was used for Tobit analysis [22].

In determining the variables involved in the DEA, the dependent variable was milk yield. As independent variables, inputs considered to have the highest effect on this dependent variable and those needed for the production were taken into consideration. As a dependent variable, annual milk yield per head (kg) was used. The independent variables included the amount of concentrate feed (kg) per head, the amount of roughage (kg), veterinary costs (TRY), other variable costs (TRY), labour (hour) and capital costs (TRY). The variable costs were included salt, electricity, water, insurance, artificial insemination, marketing, repair & maintenance and fuel costs. The labour was calculated in hours based on family and hired-labour. Capital costs consisted of depreciation and interest charges on buildings and equipment used in dairy cattle breeding.

Also, the effect of socioeconomic variables on the efficiency, including the farmer's age, the share of family labour, education level, the type of milking, experience in dairy farming, herd size and artificial insemination was calculated using censored Tobit regression analysis.

RESULTS AND DISCUSSIONS

Summary statistics of the inputs used in the analysis were shown in Table 1. The average milk yield per head produced during the lactation period in 148 enterprises was calculated as 5,075.19 kg. Milk yield per head in the minimum and maximum lactation period was determined as 1,470 kg and 7,500 kg respectively. Semerci et al. [70] determined milk yield per cow in a lactation period as 5,618.65 kg in dairy cattle enterprises in Hatay, which was consistent with our findings. It was estimated that average amount of concentrate feed was 2,992.53 kg per head and roughage feed was 2,656.07 kg. The average veterinary costs per dairy cow were TRY106.96; the other variable costs were TRY130.73, the labour usage was 103.14 hours, and the capital expenditures were TRY415.06.

Table 1. Summary statistics of the inputs used in the efficiency analysis

Variables	Min.	Max.	Average	Standard deviation
Output				
The average milk yield per head produced during the lactation period (kg)	1,470.00	7,500.00	5,075.19	1,176.57
Inputs				
Average amount of concentrate feed per cow (kg)	0.00	9,745.50	2,992.53	1,407.65
Average amount of roughage feed per cow (kg)	0.00	10,656.00	2,656.07	1,735.67
Veterinary costs per dairy cow (TRY)	0.00	600.00	106.96	78.25
Variable costs per dairy cow (TRY)	4.29	540.00	130.73	78.91
Labour used per dairy cow (hour)	2.53	649.79	103.14	85.61
Capital cost per dairy cow (TRY)	69.13	1515.91	415.06	180.90

Source: Own calculation.

DEA method was used to calculate technical efficiency in dairy cattle farms. These scores were computed as input-oriented under the assumptions of CRS and VRS. In the case of input-level measures, the objective was to reduce the amount of input in proportion to the amount of output produced.

The distribution of the technical efficiency values obtained using the DEA for input was presented in Table 2. Businesses that were found efficient were given the amount one, and efficiency value groups were given in slices of tens.

Table 2. The distribution of the technical efficiency values by DEA

Scores	Farm numbers		
	DEA-CRS	DEA-VRS	DEA-SE
1.00	21	34	21
0.91-0.99	9	16	56
0.81-0.90	19	20	35
0.71-0.80	17	23	13
0.61-0.70	26	27	11
0.51-0.60	23	15	8
0.41-0.50	16	11	3
<0.41	17	2	1
Summary statistics			
Minimum	0.23	0.38	0.32
Maximum	1.00	1.00	1.00
Average	**0.69**	**0.78**	**0.87**

Source: Own calculation.

Of the 148 dairy cattle farms surveyed, CRS found that 21 were fully efficient and VRS found that 34 enterprises were running efficiently. CRS found that 17 farms had an efficiency value below 0.41 and VRS found that only 2 of them had an amount below that number.

The mean technical efficiency score was determined to be 69% with CRS and 78% with VRS. The mean technical efficiency score of 78% with CRS means that an average operator can save 22% (1-0.78) in the inputs if they can operate at an efficient operating level. It was determined that an operator running at a minimum level with the VRS could save 62% (1-0.38) of inputs. The technical efficiency levels with VRS ranged from 38% to 100% (Table 2).

Two main factors were determined to play a role in the inefficiency of the businesses. These were scale inefficiency and input-composite inefficiency. The average scale efficiency of the dairy cattle enterprises was found to be 87%, and the majority of the farms had an efficiency score of 0.91-1.00. Thus, the inefficiency of these farms was not the scale inefficiency, so we can suggest that inefficient production resulted from input composite inefficiency [71] [59] [62] [80] [64].

In the input-oriented efficiency analysis, of the 148 dairy cattle farms, 21 constant returns to scale, 112 increasing returns and 15 decreasing returns to scale. Dairy farms with constant returns to scale were whole efficient.

According to the farm types, the highest mean technical efficiency score with CRS was determined in the 4th group at 74%. The mean technical efficiency score with VRS was the highest in the third group (81%). The scale efficiency was highest in the 4th group (92%) (Table 3).

Table 3. Average technical efficiency scores by farmer groups

Farms groups	DEA-CRS	DEA-VRS	DEA-SE
I	0.67	0.75	0.87
II	0.63	0.73	0.85
III	0.71	0.81	0.87
IV	0.74	0.80	0.92
Average	**0.69**	**0.78**	**0.87**

Source: Own calculation.

In 2003, Candemir and Koyubenbe [17] calculated dairy cattle farms' technical efficiency as 0.934 according to the DEA scale based on the assumption of CRS and 0.954 based on the assumption of VRS in İzmir. Uzmay et al. [78] determined the technical efficiency score as 0.903 according to CRS and 0.927 according to VRS by using DEA in dairy cattle farms in İzmir. Koyubenbe and Özden [49] calculated the mean technical score as 0.864 by using Stochastic Frontier Analysis (SFA) in dairy cattle farms in İzmir in 2008. Günden et al. [37] found the technical efficiency scores as 0.615 by DEA in İzmir. Parlakay et al. [64] determined the technical efficiency of the dairy cattle farm in Hatay and they [64] determine 0.64 according to CRS and 0.69 according to VRS by DEA. These scores were calculated as 0.59 and 0.83 in Adana and Hatay province by Dagistan et al. [25], 0.75 and 0.78 in Adana by Yilmaz [80] respectively.

The efficiency values calculated in the studies carried out in Izmir [17] [78] were lower than the mean efficiency score (0.87) determined in this study. Our efficiency scores were close to those found by the works done in Adana and Hatay [25] [80] and higher than those reported in the survey conducted in Hatay [64]. The efficiency values we found in this study were consistent with those reported by Koyubenbe and Özden [49]. It should be noted here that the method chosen to measure the efficiency of the dairy farms may produce different results. Efficiency values were evaluated according to the production function in SFA and to the reference enterprise in DEA. A literature review also shows that studies utilising DEA and SFA reported different efficiency scores depending on the analysis type [39] [68] [59][62] [57][49].

The number of thoroughly efficient farms by farms groups was given in Table 4. Fully-efficient farms according to CRS, VRS and SE were mostly in group 3.

As a result of the DEA, the input slacks were also determined in the farms.

Table 4. The number of whole efficient enterprises by farms groups

Farms groups	DEA-CRS	DEA-VRS	DEA-SE
I	2	3	2
II	4	7	4
III	11	19	11
IV	4	5	4
Average	21	34	21

Source: Own calculation.

An agricultural enterprise can reduce as much as the amount of slack in the input it uses without any reduction in output. The percentage of excess use in the inputs was found by dividing the average input surplus by the average input use.

Percentage of excess input usage was the highest in other variable costs per head (19.08%). This value was followed by veterinary expenses per head (11.82%), labour (11.47%), roughage (10.33%), composite feed (4.65%) and capital costs per head (3.71%). According to these results, 76 enterprises can remain at the same production level and reduce the other variable costs by 19.08% (Table 5).

The socioeconomic variables thought to affect the efficiency of the farms included the ratio of the family labour in total labour used, education level, age of the farmer, type of milking, experience in dairy farming, herd size and artificial insemination.

There were different ways in which some variables were included in the modelling studies. Some researchers directly model the values of variables, while others prefer to use dummy variables. In this study, some variables were included in the model using dummy variables according to the qualities indicated by the variables.

The relationships between the variables determined and the technical efficiency scores were computed using Tobit regression analysis. The variables' descriptions used in the Tobit regression and some statistics were given in Table 6. The model was calculated with the EViews program.

Two-limit Tobit analysis calculated the relationship between the technical efficiency values obtained by DEA-VRS approach and the socioeconomic variables and the coefficients were given in Table 7.

Table 5. Farmers using more inputs and input surpluses

Inputs	Farmer number	Average input excess	Average input usage	Percent of excess input usage (%)
Average amount of concentrate feed per cow (kg)	7	139.06	2992.53	4.65
Average amount of roughage feed per cow (kg)	1	274.27	2656.07	10.33
Veterinary costs per dairy cow (TRY)	6	12.64	106.96	11.82
Other variable costs per dairy cow (TRY)	6	24.94	130.73	19.08
Labour used per dairy cow (hour)	3	11.83	103.14	11.47
Capital cost per dairy cow (TRY)	4	15.39	415.06	3.71

Source: Own calculation.

Table 6. Definitions of variables used in two-limit Tobit analysis

Variables	Definition	Values
Share of family labour	The ratio of family labour to the total employment used	Ratio
Education	The educational background of the farmer	1= High school or higher 0=Other
Milking type	The technique or system used in milking	1=Milking by machinery 0=Milking by hand
Experience in livestock	The farmers' experience in dairy cattle breeding	Years
Herd size	Number of cattle owned by the enterprise	Head
Artificial insemination	The status regarding the use of artificial insemination	1=Uses artificial insemination 0=No artificial insemination
Age	The age of the farmer	1=40+ 0=Other

Source: Own calculation.

Table 7. Tobit regression analysis results used in determining the relationship between socio-economic variables and technical efficiency

Variables	Coefficient	Standard error	P-value
Constant	0.7582	0.1143	0.0000
Share of family labour	0.1889	0.0775	0.0148**
Education	0.0381	0.0459	0.3872
Milking type	0.0397	0.0518	0.4444
Experience in dairy cattle	-0.0018	0.0016	0.2626
Herd size	0.0008	0.0003	0.0265**
Artificial insemination	-0.1128	0.0636	0.0762*
Age	-0.0781	0.0429	0.0687*

* Important at 0.1 level; ** Important at 0.05.
Source: Own calculation.

Two-limit Tobit analysis calculated the relationship between the technical efficiency values obtained by DEA-VRS approach and the socioeconomic variables and the coefficients were given in Table 7.

There was a definite and statistically significant (5%) relationship between the technical efficiency scores and the ratio of the family labour force in the total labour force. It means that as the ratio of family labour increases, the efficiency scores increase. In the case of farms using the family labour because they are self-employed and therefore they were more self-sacrificing and were to obtain more efficiency. This finding collaborates with Curtis et al. [24] in Wisconsin, Hallam and Machado [40] in Portuguese dairy farms and Zhu et al. [82] in Netherlands dairy farms. Also, Latruffe et al. [51] found that family labour was important for Poland dairy farm efficiency. On the contrary, Gül et al. [34] found an inverse relationship between labour use and effectiveness in goat production. Zhu et al. [82] declared that higher share of family labour decreased efficiency score of dairy farms in Germany and Sweden. Özden [60] determined non-family labour decrease efficiency score of dairy farms in Aydin. However, Alemdar et al. [3] found that family labour did not have a significant effect on inefficiency score of dairy farms in Adana.

In this study, the education level of the farmers was modelled as a dummy variable. The farmers with high school or higher education (1) and those with lower education level (2) were classified into two groups to investigate the effect of education level on efficiency by using limited Tobit regression analysis. The average education level was at the primary school level. Approximately 24.33% of the farmers surveyed had high school or higher education. The technical efficiency values had a positive but statistically insignificant relationship with education level. The positive correlation between education and efficiency scores shows that farmers with higher education work more efficiently than those with lower education level. Education level promotes the adoption of innovations and keeping up with latest advances.

This finding collaborated with several studies in Turkey [4] [35] [26] [34][60]. Mor and Sharma [54] found that inefficiency scores decline with the increased years of formal education in India. Latruffe et al. [51] determined lower educated farmers to be less efficient in Poland. However, some researchers ([5][21][46]) indicated a negative correlation between education level and efficiency scores. But, some researchers did not find any relationship with both variables [73][74][11][78][30][63][64][26].

The method of milking was included in the models as a dummy variable. The machine-milking enterprises were involved in one group (1), while the manual milking farms were in the other unit (0). About 85.81% of the farms were using machinery for milking. We found that the type of milking had a positive but statistically insignificant impact on the efficiency. The positive relationship between the milking method and efficiency indicates that the enterprises using machinery work more efficiently than those using manual milking. The use of milking-machinery was higher as compared to previous studies. In fact, 8.66% of the machine-milking enterprises had fixed milking units and cooling tanks.

The effect of farmer's experience on the efficiency of dairy cattle was adverse and statistically insignificant. As the experimentation increased, the efficiency score decreased, so it can be suggested that the more experienced farmers try to maintain traditional production techniques, while the younger generation tends to increase their productivity by using new technology.

Gül [33] determined a definite relationship between experience level and efficiency score. Just as several others did, such as; Bravo-Ureta and Rieger [13], Alemdar and Işık [4], Gül et al. [35], Uzmay et al. [78], and Parlakay et al. [64]. However, Alemdar and Ören [5] reported a negative correlation between experience level and efficiency score in their work.

The impact of herd size on efficiency was positive and statistically significant at the level of 5%. It can be said that as the herd size increases, the efficiency score increases. It was widespread that the herd size affects improving productivity by making the resource usage useful.

The study conducted by Yılmaz [80] in Adana determined a positive and statistically meaningful correlation between the technical efficiency scores and the herd size of the farms by the DEA and Gül et al. [34] found a direct correlation between herd size and efficiency scores in goat production. In their study carried out in Adana, Şahin et al. [69] stated that dairy cattle farming was a profitable production area, with much higher profitability in large enterprises. Tauer and Belbase [74] claimed that the greater cow numbers would increase the efficiency score of New York dairy farms. Similar results were found by Featherstone et al. [28] in Kansas, Bravo-Ureta and Rieger [13] in New England, Brümmer and Loy [15] in Germany, Binici et al. [11] in Burdur, Demircan et al. [26] in Burdur, Parlakay et al. [64] in Hatay. Also, Zhu et al. [82] found that larger size dairy farms increased efficiency in Germany and Sweden. However, Bravo Ureta [12] in New England; Ahmad and Bravo-Ureta [2] in New England; Dagistan et al. [25] in Adana and Hatay, Özüdoğru [63] found a negative effect between efficiency score and herd size for dairy farms. However, Alemdar et al. [3] determined herd size not have a significant effect on inefficiency score of dairy farms.

These findings show that it was necessary to take policy measures that encourage the growth of the farms.

Artificial insemination was included in the model as a dummy variable. There were two groups: enterprises that opted for artificial insemination (1) and those using no artificial insemination (0). About 90.54% of the farms were utilising artificial insemination. Artificial insemination was found to have an adverse and statistically significant (10%) effect on efficiency values, which suggests that the enterprises using artificial insemination operated less efficiently than those not using it. It could be due to the high number of insemination attempts per pregnancy, cost of artificial insemination, and its high failure rate.

Of the socioeconomic variables, the age of the farmer was also included in the model as a dummy variable. The farmers aged 40 or above were in one group (1), while those younger than 40 were included in the other unit (0). The farmers' age variable had a negative coefficient. It meant that adversely affected on the efficiency score, which was statistically significant at 10% (Table 7). The negative correlation between the age and efficiency values indicates that the farmers older than 40 were less efficient scores than younger ones. The result of this study also corroborates with Brümmer and Loy [15], Alemdar and Işık [4] and Gül et al. [35]. They found that elderly farmers were fewer efficiency scores than younger farmers.

However, Alemdar and Ören [5] and Koc et al. [46] determined that older farmers have more efficiency scores than younger farmers. However, Tauer and Belbase [74], Bravo-Ureta and Rieger [13], Tauer [73], Latruffe et al. [51], Binici et al. [11], Gelan and Muriithi [30], Uzmay et al. [78], Özüdoğru [63], Özden [60] determined farmers' age not have a significant effect on efficiency score of dairy farms.

CONCLUSIONS

This study examined the efficiency in the dairy cattle farms in the Eastern Mediterranean area of Turkey by using DEA method. The average technical efficiency score with DEA-CRS was calculated as 69%, whereas this value was 78% with DEA-VRS. The mean technical efficiency value of 78% with the DEA-VRS means that the average enterprise can save 22% (1-0.78) in the inputs if it can operate efficiently. Specific socioeconomic variables including the share of family labour, herd size, artificial insemination, and farmer's age had a significant impact on the farms' efficiency values. The results indicated that the efficiency score of production was significantly low, which suggests that producers can produce the same output using less input. Also, farmers can increase efficiency by increasing the family labour's ratio in total labour and the size of their herds while lowering the amount of artificial insemination.

Average efficiency scores calculated in the study are in line with those obtained in other studies conducted in the region. The scores obtained are not sufficient. These scores can be increased by efficient use of input combinations used in production and other measures to be taken. It has been specified that artificial insemination costs reduce efficiency. It can be said that the artificial insemination is affected more than once because it increases the costs. Improvements in this subject can improve efficiency. It is also seen that machine milking improves the efficiency. Dissemination of machine milk and replacement of the used dairy machines with more advanced ones may provide increased yield.

Some improvements in the production techniques in the enterprises can lead to more efficient production. The businesses can reduce costs by staying at the same production level.

Especially in developing countries, the high inputs costs in production increase the importance of efficiency studies. Therefore, the results of the studies into production efficiency should be delivered to farmers through the use of agricultural publishing services so that they can streamline their production activities to achieve better efficiency.

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