

# Analysis of technical efficiency in milk production: a cross-sectional study on Turkish dairy farming

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**ABSTRACT** - We analyzed the efficiency of farmers in the dairy production using cross-sectional data collected from 92 sample dairy farmers in the West Mediterranean Region of Turkey. The study used the Stochastic Frontier Analysis (SFA) to measure the technical efficiency of farmers in milk production. The technical efficiency of the sample of dairy farms ranged from 0.30 to 1.00. The mean efficiency of the sample of farmers was 0.55, indicating the presence of substantial scope for improving the competitiveness of dairy sector in the region by improving the efficiency of farmers. While some of these variations could be attributable to random factors, we calculated that 97.3% of the variations was attributable to the inefficient use of inputs, leaving only 2.7% to random factors. This shows the possibility of increasing average output by about 0.45 without the use of additional inputs. The most significant factors affecting the efficiency of dairy production were household size, total number of cattle, and ratio of the total number of dairy cows to total number of cattle, technological level, barn type, and production of maize silage. This study, by measuring the levels of efficiency and by identifying factors explaining the differences in efficiency, gives useful information for designing policy interventions targeting to improve the competitiveness of the Turkish dairy sector.

**Keywords:** dairy production, production efficiency, stochastic production frontier, Turkey



## Introduction

Dairy farming is an important sector in the rural economy of Turkey. It makes substantial contributions to Turkey's economy by providing high-value food and employment opportunities for many rural households. In addition, this sector is an important source of income for farm households. The dairy sector in the country is characterized by a relatively large number of animals with very low yields. In comparison to average milk yield per lactation of 6.55 tons in European Countries (EU-28), (EUROSTAT, 2015), the equivalent amount of 2.97 tons in Turkey is quite low (TURKSTAT, 2015). Besides, dairy farming is dominantly carried out by family farms as a secondary small-scale economic activity. Consequently, the sector is not very competitive.

As it is known, Turkey is a candidate country for EU membership. Thus, to capture the potential economic gain from the wider EU market, the country has to improve the competitiveness of its dairy sector by improving the efficiency of resources, introducing new technologies and improved practices (e.g., fixed milking unit, cooling tank, free-stall feeding system, and semi-opened barn etc.) that are more profitable and support its sustainable development.

The dairy sector in the country still produces milk at the rate of 2.97 ton/cow/lactation, which is quite low for the European standards (EUROSTAT, 2015). The dairy farming policy objective of the Turkish government has evolved from one that concentrated on increasing productivity towards one that tries to enhance the sustainable development of a competitive dairy farming sector (Yilmaz and Ata, 2016). Thanks to government subsidies and incentives, there have been important advances in dairy farming in Turkey. Substantial increases in the number of dairy cows and in milk production have occurred (TURKSTAT, 2015). According to official statistics, 16.9 million metric tons of milk is produced annually, out of which 91.2% is obtained from cattle. The total number of cattle in Turkey increased from around 11.2 million in 2000 to 14.1 million in 2014, equivalent to a 26.3% growth. Similarly, the total annual cow milk production, which was around 8.9 million tons in 2000, increased to 16.9 million tons in 2014, an increase of 87.7% (TURKSTAT, 2015).

Milk production is an important branch of the livestock sector in Burdur Province, the study area. Most farms in the area are family-based dairy farms producing dairy milk as their main economic activity. Of the total number of cattle in Turkey, 1.4% is found in Burdur. However, the productivity of the dairy sector in the area is low. A major challenge for the sector is how to improve its profitability. Increasing the profitability of the sector can also be possible under the current technologies without changing the production technology (technologies in dairy farming; improved, innovative or traditional, extensive or intensive). The scope for improving milk production with the existing technology depends on the level of technical inefficiency of dairy farmers in the study area. The question is thus: to what extent dairy farmers in the study are efficient in utilizing the available resources?

Efficiency is an old concept, and it was Farrell (1957) who pioneered the empirical measurement of productive efficiency. Using an input-orientated approach, he showed how to decompose the economic efficiency of a farm into its technical and allocative efficiency components. Many types of research have specifically applied Stochastic Frontier Analysis (SFA) for the measurement of technical efficiency in the dairy sector (Reinhard et al., 2000; Lawson et al., 2004; Abdulai and Tietje, 2007; D'Haese et al., 2009; Hailu and Deaton, 2015; Hazneci and Ceyhan, 2015).

The objective with this study was to investigate the factors affecting the technical inefficiency of dairy farmers in milk production in Burdur Province of Turkey. It is expected that the findings of this will provide dairy farmers' cooperatives, dairy sector representatives, and policymakers valuable information for improving the performance of the dairy sector in the province.

## Material and Methods

The study was conducted in selected areas of Burdur province, which is located in the Southwest of Turkey. It shares border with Muğla and Antalya in the South, Isparta in the East, Afyon in the North, and Denizli in the West. It has a population of around 260,000 people and is geographically located between 36°53' N–37°50' N and 29°24' E–30°53' E, covering an area of 6,887 km<sup>2</sup>. Burdur is found in the "Lakes Region" of Turkey, and Burdur Lake is the largest among the many lakes found in the province. Burdur has a continental Mediterranean climate. Accordingly, summer is hot and dry, while winter is cold. The annual the temperature ranges from 6.4 to 21.6 °C and the annual average rainfall is 405 mm (Yigitbaşıoğlu and Ugur, 2010).

Dairy farming is the primary agricultural activity in Burdur. From the heifer stockbreeding and sales performed in Turkey, 97% of the cattle are local breeds, and the production system is largely traditional. However, some transitions from family stockbreeding to modern dairy farms have been observed in recent times. Approximately 17,679 dairy farms existed in 2014 in the province (Anonymous, 2015). The number of cattle in the province increased over the period 2000-2014. In Burdur Province, the total number of dairy cows, which was around 105,000 in 2000, increased to 198,000 in 2014, an increase of 88.7%. Similarly, the total milk production, which was around 129,000 tons in 2000, increased to 333,000 tons in 2014, an increase of 157.5% (TURKSTAT, 2015). These figures show the increased economic importance of the dairy sector in the province.

The standard microeconomic theory presupposes the full and efficient utilization of resources, but since the pioneering work of Farrell in 1957, many empirical studies provided evidence for the presence of diverse forms of inefficiencies. Although the initial work of Farrell was based on linear programming approach, his work inspired, among others, Aigner et al. (1977) and Meeusen and van Den Broeck (1977) to develop the alternative econometric approach for estimating the technical efficiency through the Stochastic Frontier Approach (SFA). The theory and concept of measurement of technical efficiency are founded on production functions, which locate the average response functions. By positioning firms in an input-output framework, efficiency analysis methods establish the benchmarks against which technical, allocative, and economic efficiencies can be measured. The frontier approach, by allowing the average response functions to shift to the maximum outputs, establishes the locus of efficient firms as benchmarks. The performance of firms will be then evaluated in reference to the benchmark firms representing the frontier. Literature divides methods of efficiency measurements into two: nonparametric deterministic data envelopment analysis (DEA) and parametric stochastic frontier analysis (SFA). Both methods are extensively used in management science (Coelli et al., 1998) and are also widely applied in economics.

Although many alternative specifications are available, Cobb-Douglas functional form is widely used in empirical studies. This study specifies the stochastic production frontier (SPF) using a Cobb-Douglas functional form as applied in Battese and Coelli (1995). In logarithmic form, the model is specified as:

$$\ln Y_i = \beta_0 + \sum_{j=1}^2 \beta_j \ln X_{ji} + v_i - u_i \quad (1)$$

$$i = 1, 2, \dots, N = 92$$

and

$$u_i = \delta_0 + \sum_{m=1}^{11} \delta_m Z_{mi} \quad (2)$$

in which  $\ln$  denotes natural logarithm;  $Y_i$  is the annual milk output of farm  $i$  measured in kilograms;  $X_{1i}$  is the annual input of concentrate feed in tons;  $X_{2i}$  is the annual input of roughage feed in tons; and  $Z_{mi}$  are socioeconomic and other variables determining inefficiency.  $v_i$  is asymmetric, identically and independently distributed error term with mean and variance of  $N(0, \sigma_v^2)$ . It represents random variations in production attributed to random exogenous factors, such as measurement errors, unobserved variables, and statistical noise.  $u_i$  is a one-sided non-negative error term that represents the technical inefficiency of firm irrelative to its counterpart on the stochastic frontier.

The variables ( $Z_{mi}$ ) considered in this study were defined as follows:

$Z_{1i}$  = farmer age defined as the age of the household head in years;

$Z_{2i}$  = experience of the farmer measured in terms of years of dairy farming experience;

$Z_{3i}$  = education level of the farmer measured in terms of schooling years;

$Z_{4i}$  = family size measured as the number of persons in the household;

$Z_{5i}$  = total number of persons who work at the dairy farm;

$Z_{6i}$  = total number of cattle in the dairy farm;

$Z_{7i}$  = ratio of the total number of milking cows to the total number of cattle in the dairy farm;

$Z_{8i}$  = technological level represented as a dummy variable, which is equal to 1 if the farmers have a fixed milking unit and cooling tank and 0 otherwise;

$Z_{9i}$  = feeding type represented as dummy variable, which is equal to 1 if the farmer used a free-stall feeding type and 0 otherwise;

$Z_{10i}$  = barn type is represented as dummy variable, which is equal to 1 if the farmers have the semi-opened barn and 0 otherwise;

$Z_{11i}$  = silage production represented as dummy variable, which is equal to 1 if the farmer produces maize silage and 0 otherwise.

Following Coelli and Perelman (1999), the technical efficiency of farm  $i$  equals:

$$EEF_i = E[\exp(-u_i)|\varepsilon_i] = E[\exp(-\delta_0 - \sum_{m=1}^{10} \delta_m Z_{mi})|\varepsilon_i], \quad (3)$$

in which  $E$  is the expectation operator.

The technical inefficiency of farm  $i$ , i.e.  $u_i$ , is the deviation from the estimated Cobb-Douglas SPF, conditional upon the observed value of  $\varepsilon$ . Maximum likelihood is used to estimate the unknown parameters of the Cobb-Douglas stochastic frontier (Equation 1) and the measure of inefficiency (Equation 2) simultaneously. The likelihood function is parameterized in terms of the variance parameters,  $\sigma^2 = \sigma_v^2 + \sigma_u^2$  and  $\gamma = \frac{\sigma_u^2}{\sigma^2}$  (Battese and Coelli, 1995), in which the  $\gamma$  parameter has a value between 0 and 1. A value  $\gamma$  of 0 means that the deviations from the frontier are simply due to noise with no inefficiency and a value of 1 means that the deviations are entirely due to technical inefficiency. We used FRONTIER 4.1 software developed by Coelli (1996) to estimate the parameters, firm-level efficiency, and mean efficiency levels.

The study used data collected from 92 dairy farmers in Burdur Province of Turkey. Burdur Province was selected purposively because most of the farms are classified as family farms, and dairy production in the area is the main economic activity. Similarly, from the total of seven districts of the province, seven districts were purposively selected based on the distribution of dairy farms. The number of sample farms in each district was allocated proportionally to the number of dairy farms. Finally, 92 sample farms were selected randomly.

The standard deviations show that the sample reflected the large diversity in terms of size of dairy farms in the research area (Table 1). The average cattle holdings were found to be 60.25 cattle per farm with a range of 18-156 cattle. Farms had on average hold 27.42 dairy cows. The maximum milk production in the sample was 399 tons, and the minimum was 45 tons. The average milk production

**Table 1 - Descriptive statistics of variables inputs, output, and inefficiency effects**

Variable	Mean	SD	Max	Min
<b>Output</b>				
Milk production (ton/farm/year)	152.58	85.40	399.00	45.00
<b>Production function variables</b>				
Concentrate feed intake (ton/farm/year)	102.39	52.84	235.00	24.00
Roughage feed intake (ton/farm/year)	821.00	59.00		
<b>Inefficiency function variables</b>				
Age of farm holder (year)	42.20	10.05	73.00	25.00
Farmer experience (year)	15.47	7.45	41.00	3.00
Education level of farm holder (year)	7.55	2.83	15.00	5.00
Number of household population	4.13	1.25	8.00	2.00
Labor (full-time equivalents)	2.54	0.97	6.00	1.00
Number of cattle (head/farm) <sup>1</sup>	60.27	32.80	156.00	18.00
Dairy cows:total cattle ratio (%)	0.46	0.08	0.74	0.31
Dairy farms that have fixed milking unit and a cooling tank (%)	50.00			
Use the free-stall feeding system (%)	32.61			
Dairy farms that have the semi-opened barn (%)	54.35			
Dairy farms that grow maize silage (%)	76.09			

<sup>1</sup> Number of total cattle: 5,545.

per farm in the sample farm was 152.58 tons/year. The average milk production per cow in the sample was 5.52 tons/lactation in research area. These findings show that milk yield in research area and Turkey (2.97 ton/cow/lactation) is below the European average (6.55 ton/cow/lactation).

The range for concentrate feed intake was 24-235 tons per farm, and the average was 102.39 tons. The range for roughage feed intake was 59-821 tons per farm, and the average was 320.98 tons. Forage, grain, and maize silage production are very important in dairy farms. Mean forage and grain production area was 17.58 ha, the average quantity of forage and grain production was 332.94 tons per farm. Mean maize silage production area was 6.50 ha with the average quantity of maize silage production of 268.46 tons per farm. The rate of dairy farmers growing maize silage was 76.09% (Table 1).

In addition to the above input variables, household socioeconomic and farm-level characteristics were included. The average age of farmers in our sample was 42.20 years with the youngest being 25 years old and the oldest being 73 years old (Table 1). The average household size was 4.13. The surveyed farms employed between one and six full-time family and hired laborers. The average full-time equivalent employment was 2.54 persons per farm. Average years of education of farm household head were 7.55 years. A few farmers ( $n = 4$ ) had a university degree. The percentage of farmers who used agricultural credit for dairy farming was 57.61%. All the sample farms were found to be members of an agricultural cooperative (Table 1).

The dairy farms in the study area differ in their mode of production in many ways. The study identified four production parameters. In the study area, about 50% of the dairy farms have more advanced facilities than the others. This means that these farms have fixed milking unit and the cooling tank. In addition, dairy farms in the area also differ in their feeding system. While 67.39% of the farms were found to use tie-stall barns, where each lactating cow is held and fed separately, the remaining (32.61%) were found to use a free-stall barns system, which allows all cows to move freely in the stalls. Similarly, while 76.09% of the farms grow maize silage and feed cows, others (23.91%) do not grow maize silage. Finally, dairy farms also differ in the type of their barns. While 54.35% of the dairy farms were found to use a semi-closed barn, others (45.65%) were found to use open barn.

The descriptive results show that the sample dairy farms in the study areas considerably differ in the level of output, input use, socioeconomic characteristics, and technical aspects of their production systems. Interest arises to explain the implications of these differences on the efficiency of dairy farms.

## Results

The SPF model was specified using a Cobb-Douglas function for the analysis of technical efficiency of dairy farms in Burdur province. From the two inputs considered in the estimation of the production frontier, the concentrate was found to positively determine the milk production of the farm at a level of  $P < 0.001$ . Since the Cobb-Douglas functional form was specified for the estimation of the production frontier, the coefficients represent input elasticities. Accordingly, the results imply that 1% increase in the level of concentrate increased milk production by 51% (Table 2). Contrary to the expectation, no evidence was found on the effects of roughage feed in determining milk output.

To test the presence of inefficiency, we used a log-likelihood ratio test. With the estimated value of  $\sigma^2 = \sigma_v^2 + \sigma_u^2 = 0.01$  and  $\gamma = \frac{\sigma_u^2}{\sigma^2} = 0.99$ , the null hypothesis that  $\gamma = 0$  is rejected ( $P < 0.001$ ). Likelihood-Ratio (LR) Tests statistics is 75.64, indicating the presence of technical inefficiency. The relative contribution of inefficiency effects in the total variance term  $\gamma$  is given by  $\gamma[\gamma + (1-\gamma)]\pi/(\pi-2)$ . This is because the variance of  $u_i$  is  $\pi/(\pi-2)\sigma^2$ , not  $\sigma^2$  (Coelli et al., 1998). Several hypothesized variables expected to explain inefficiency differentials among farmers in the study area were estimated together with the SPF model, using a one-stage estimation procedure. The variables considered in this study can be categorized into socioeconomic and demographic factors (age, experience, education, and family size) and resource and technical factors (number of cattle, corn silage production, ratio of total number of dairy cows to total number of cattle, technological level, feeding type, and barn type).

Among the hypothesized socioeconomic and technical factors that were expected to explain efficiency differentials among sample dairy producers in the study areas, household size, number of cattle, proportion of dairy cows in the total cattle, milk facilities, barn type were found to be strongly significant at 1% level. The negative signs in all these coefficients indicate that these parameters negatively affect the level of inefficiency of dairy farms. In other words, these parameters positively explain the observed differences in the level of efficiency among sample dairy farms. Similarly, growing maize silage was also found to be 5% significance level, strongly suggesting that the differences in the level of efficiency observed among dairy farms are explained by the use of maize silage. On the contrary, age, experience, and education levels of the sample dairy farmers, number of workers in the farm, and feeding type were found to be non-significant (Table 2).

Given the functional form used, estimation procedure implemented, and type of distribution assumed for the inefficient effect  $u_i$ , the mean technical efficiency was estimated to be 55% (Table 3). This means that an average dairy farmer can increase milk output by 45%  $((1-0.55)*100\%)$  by improving the utilization of its current inputs, i.e., without using additional inputs. Technical efficiency was calculated as 55% on farm. These results indicate that there are some opportunities for improving resource use efficiency. The results imply that dairy farmers can reduce inputs by at least 45%, while remaining at the same production level.

Moreover, there was also considerable variation in the levels of technical efficiency among dairy farms in the study area. The efficiency level ranged from a minimum of 0.30 to a maximum of 1.00. The frequency distribution shows that most of the farmers (about 87%) have technical efficiency scores of less than 0.70 (Figure 1).

**Table 2 - Maximum likelihood estimates of Stochastic Frontier and technical inefficiency effect models**

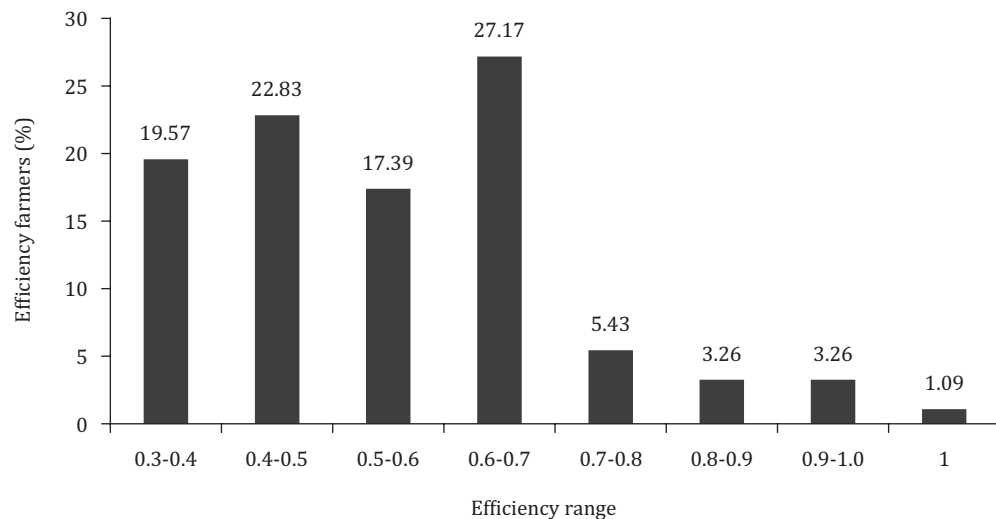
Variable	Parameter	Coefficient	t-ratio
Stochastic Frontier			
Constant	$\beta_0$	2.87	6.54**
Ln(concentrate feed)	$\beta_1$	0.51	10.26**
Ln(forage feed)	$\beta_2$	0.05	1.19
Inefficiency model			
Constant	$\delta_0$	1.67	7.05**
Age	$\delta_1$	-0.001	-0.77
Experience	$\delta_2$	-0.001	-0.57
Education	$\delta_3$	-0.001	-0.24
Number of household population	$\delta_4$	-0.02	-2.14**
Number of people who work on farms	$\delta_5$	-0.006	0.35
Number of cattle	$\delta_6$	-0.004	-4.79**
Dairy cows:total cattle ratio	$\delta_7$	-0.92	-5.03**
Technological level	$\delta_8$	-0.11	-2.64**
Feeding type	$\delta_9$	-0.0008	-0.03
Barn type	$\delta_{10}$	-0.10	-2.20**
Maize silage production	$\delta_{11}$	-0.06	-1.80*
Variance parameter			
Sigma-squared $\sigma^2 = \sigma_v^2 + \sigma_u^2$		0.01	6.16**
Gamma $\gamma = \frac{\sigma_u^2}{\sigma^2}$		0.99	15.98**
Log-likelihood function		84.01	
Likelihood-ratio Tests (LR statistic)		75.64	

\*\* Significant at a level of 1%.

\* Significant at a level of 5%.

**Table 3** - Frequency distributions of technical efficiency scores

Efficiency score	Number of dairy farms	Percent
Equal to 1	1	1.09
$\geq 0.90 < 1.0$	3	3.26
$\geq 0.80 < 0.90$	3	3.26
$\geq 0.70 < 0.80$	5	5.43
$\geq 0.60 < 0.70$	25	27.17
$\geq 0.50 < 0.60$	16	17.39
$\geq 0.40 < 0.50$	21	22.83
$\geq 0.30 < 0.40$	18	19.57
Mean	0.55	-
Minimum	0.30	-
Maximum	1.00	-
Standard deviation	0.16	-

**Figure 1** - Proportion of farmers in the efficiency group.

## Discussion

The estimation result of SPF and the test statistics showed that there was considerable inefficiency among sample dairy farms in the study areas. The mean efficiency of 55% indicates the possibility of increasing output (or reducing inputs) by 45% given the existing level of inputs (output). However, this potential or possibility can be realized if the dairy farms eliminate their inefficiency. The mean efficiency score suggests considerable scope for increasing output and/or reducing inputs by improving the technical efficiency of dairy farms. However, it is important to note that the result shows local conditions as the analysis was made by taking the relatively best farms in the area as fully efficient. It can thus underestimate the potential for improvements. This is because if the system as a whole is inefficient, those farms that are considered as fully efficient locally could become inefficient when they are compared with more efficient farms elsewhere. In short, the frontier represents only the locus of points of maximum possible output in the production environment under consideration. Previous studies on efficiency of dairy farms in Turkey have found mean production efficiency scores of 50% in Burdur province (Binici et al., 2006), 78% in Adana province (Alemdar et al., 2010), and 89% in Samsun province (Gunduz, 2011).

The major interest behind measuring technical efficiency level is to know what factors determine the inefficiency differences among farmers. Empirical literature of efficiency analysis shows that the determinants of efficiency/inefficiency vary considerably depending on the socioeconomic and technical context under consideration. The age of the farmer was hypothesized to determine the level of inefficiency. However, the direction of its effects could be positive for some ranges and negative for the remaining ranges. The theoretical basis of this is that people are more energetic, active, and able to make well-thought decisions as their age increases and, as a result, their efficiency increases (Kitila and Alemu, 2014). However, such increasing trend cannot persist throughout their life, and beyond a certain age, all the physical and mental strength start turning down, and a declining trend in efficiency will follow (Gelaw and Emanu, 2008). The result of the estimation shows that age is statistically not significant (Table 2). The other demographic variable hypothesized to positively affect efficiency was the experience of the farmer in dairy husbandry. Conceptually, the technical and managerial skill of the decision maker increases with the length of experience. Contrary to the expectation, experience was found to be statistically not significant.

Similarly, the education level of the sample farmers was hypothesized to be positively associated with efficiency. Similar to experience, education is conceptualized to increase efficiency by improving the technical and managerial skills and knowledge of the farmer in properly utilizing inputs (Binici et al., 2006). In this study, however, education was not found to determine technical efficiency of farmers in the study area. Household size measured as persons living in the family was hypothesized to determine efficiency positively. The result is consistent with prior expectation. The coefficient for the number of people who work on farms had a negative sign, but was found statistically not significant. Studies by Ajibefun (2002), Parikh and Shan (1996), and Gelaw and Emanu (2008) found similar results. The total number of cattle and the ratio of the total number of dairy cows to the total number of cattle are found to positively and statistically determine the efficiency of dairy farms significantly ( $P < 0.01$ ). These findings are consistent with previous studies (Binici et al., 2006; Alemdar et al., 2010).

In addition to the above socioeconomic characteristics of the dairy farmers, differences in other technical aspects of the dairy farms in the area were also found to determine their efficiency levels. Among the production aspects hypothesized to affect efficiency differentials, all, except the feeding type, were found to significantly determine the efficiency of dairy farms. Despite our hypothesis that farms with a tie-stall feeding system would be more efficient than farms that use the free-stall system, we found no evidence on the effect of feeding system on efficiency. However, we found that the presence of fixed milking unit and cooling tanks, and the use of maize silage and semi-open barn positively affect the efficiency of farmers. Dairy farms equipped with the fixed milking unit and cooling tanks and farms that use a semi-open barn system were found to be more efficient than their counterparts. Feeding maize silage could affect the efficiency of farms by improving the performance of dairy cows in converting the concentrate and forage feeds into milk outputs. The implications are that dairy farms in the area can reduce their inefficiency by improving the production facility of farms, by using maize silage, and by using semi-open barn.

## Conclusions

This study analyzed the technical efficiency of dairy farmers by using a sample of 92 dairy farmers from a province in the West Mediterranean Region of Turkey. Using Cobb-Dougllass specification of the SPF model, we found a mean efficiency score of 0.55. This shows that dairy farmers, on average, are 45% less efficient compared with the most efficient farmers in the area. In addition, there were also considerable differences in the level of inefficiency among farmers. Therefore, there is considerable inefficiency in milk production in the area. This inefficiency, however, can be improved if factors that determine the level of inefficiency of farmers in the production of milk in the study area are identified.

The estimated SPF model, together with the inefficiency parameters, shows that household size, total number of cattle, and ratio of total number of dairy cows to total number of cattle, technological level,



barn type, and maize silage grown on farms were found to explain inefficiency of the farmer in the production of milk. These factors have important policy implications in mitigating the existing level of inefficiency of farmers in milk production. Such information is important for designing appropriate policies and programs to improve the economic profitability of the sector.

## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

Conceptualization: H. Yilmaz, F. Gelaw and S. Speelman. Data curation: H. Yilmaz, F. Gelaw and S. Speelman. Formal analysis: H. Yilmaz, F. Gelaw and S. Speelman. Funding acquisition: H. Yilmaz and S. Speelman. Investigation: H. Yilmaz and S. Speelman. Methodology: H. Yilmaz, F. Gelaw and S. Speelman. Project administration: H. Yilmaz. Resources: H. Yilmaz and S. Speelman. Software: H. Yilmaz, F. Gelaw and S. Speelman. Supervision: H. Yilmaz, F. Gelaw and S. Speelman. Validation: H. Yilmaz, F. Gelaw and S. Speelman. Visualization: H. Yilmaz, F. Gelaw and S. Speelman. Writing-original draft: H. Yilmaz, F. Gelaw and S. Speelman. Writing-review & editing: H. Yilmaz, F. Gelaw and S. Speelman.

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