Technical efficiency of sheep farming in the West Mediterranean Region (TR61) of Turkey

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Abstract

The West Mediterranean Region is suitable for small ruminant breeding in terms of its natural resources, and it constitutes employment for small family farms. The material of the research was the primary data obtained by the survey method from sheep farmers. Also, we used data obtained from TURKSTAT and Breeding Sheep Goat Breeders' Association about the West Mediterranean Region. We applied the stratified sampling method to the population of the research region and calculated the sample volume as 102 farmers for sheep farms. We used Stochastic Frontier Analysis to measure the efficiency of enterprises. Average technical efficiency of sheep farms was determined to be 0.77 in the region. We determined that there was a positive and significant relationship between meat production and concentrated feed cost, operating capital, veterinary costs and marketing costs. In the technical inefficiency model, the feeding system and additional feeding variables were found to be positive and significant. However, the frequency of meeting with technical staff and the farms' activity field variables were determined to be meaningful and negative. It was observed that the sheep farms which were examined in the research area could increase their enterprises' efficiency by making better use of their existing resources.

Keywords: Sheep farms. Technical efficiency. Stochastic Frontier Analysis. Western Mediterranean.

1. Introduction

Turkey, which has a lot of small family businesses, has natural resources, favourable meadows and pastures for grazing animals in terms of the sheep breeding. Similarly, the West Mediterranean Region, which includes the provinces of Isparta, Burdur and Antalya, is an essential region for small ruminant breeding and was determined as a research area.

Sheep farming is generally to be extensive farming in Turkey. The obtained animal products constitute the fundamental food source of low-income agricultural enterprises, contribute to the farms' income and create employment opportunities for the labour force (Dellal et al., 2002).

According to the 2018 data of Turkish Statistical Institute, 10.23% of the total red meat production of Turkey was provided from small ruminants and 9.01% of which was supplied from sheep meat production. 9.1% of the total milk production of Turkey was obtained from small ruminants, 6.5% of which was sheep milk (TUIK, 2019a). Livestock value was around 146.2 billion TRY in Turkey. 37.1 billion TRY of this total amount was obtained from sheep, and sheep value rate was 20.31% (TUIK, 2019b).

Studies that were about the efficiency of the sheep farms in Turkey is limited. Therefore, efficiencies of the sheep farms in the West Mediterranean Region were researched by efficiency analysis. So, to determine their farm efficiency, to evaluate the factors affecting the efficiency or inefficiency and to improve their profit level were aimed.

2. Literature Review

Different parametric methods were studied on efficiency researches in agricultural businesses. For example;

Tauer and Belbase (1987) determined the technical efficiency of New York dairy farms with SFA (Stochastic Frontier Analysis) and Cobb-Douglas production function. They found that on average 69% of businesses worked effectively. All input variables were found to be statistically significant at the 0.01 level and positively correlated to efficiency.

Sharma et al. (1999) determined the level of technical, allocative and economic efficiency of pig producers in Hawaii. For this purpose, they used both SFA and Data Envelopment Analysis (DEA) methods. They determined a positive interaction between farm size and efficiency.

Kompas and Che (2004) used the SFA and Technical Efficiency Model for Australian dairy farms. According to the results of the research, animal capital, labour force, land size, feed cost, material and service cost and plant and operating capital were found to be statistically significant at the 0.01 level. It was also stated that the others except for the 1998 drought variable were positive. In the inefficiency model, while the farm area used by the milking herd was found to be positive and statistically insignificant, the feeding concentration per cow and the ratio of irrigated land were negative and significant.

Johansson (2005) calculated the technical, economic and allocative efficiency of dairy farms in Sweden. DEA and SFA were used in analysis. As a result of the research, it was reported that the use of DEA was more practical in terms of providing ease of use. Technical, allocative and economic efficiency values in enterprises were calculated as 77%, 57% and 43%, respectively.

Wubeneh and Ehui (2006) aimed to examine the effect of credit on the farmers' adoption of technology in the region of Selale and Debre Libanos. They used the Cobb-Douglas production function. They found that expenditures of concentrate feed, feeding and veterinary services were significant for milk production. The average efficiency level of farmers was 79%. The findings showed that there was systematic inefficiency in milk production. They stated that by providing training of farmers on appropriate feeding, breeding, milking, cleaning of cows and by improving milk storage, marketing and other management skills would be achieved an average of 21% better production in current technology.

Parlakay et al. (2015) aimed to estimate the technical efficiency of the dairy farm by using the DEA method in Hatay province of Turkey. In the efficiency model, the amount of annual milk production, concentrate feed, roughage feed, veterinary costs and labour force were used as variables. The average technical efficiencies were determined as 0.64 and 0.69, respectively. They found that the efficiency was associated with the size of the herd, rate of concentrate feed and the experience of the farmers to be positive.

Gül et al. (2016) estimated technical efficiency using DEA in goat farming in Isparta province. Ninety-two goat enterprises were interviewed in the research area. The most important factors affecting the efficiency of goat production were farmer experience, cooperative membership, milk yield per goat, family and temporary labour force. They stated that technical efficiency could be increased by providing well-organised training-extension studies for farmers, and research and development programs on goat breeding. Also, they noted that the wrong input usage mostly caused ineffectiveness.

Oğuz and Canan (2016) aimed to calculate the technical efficiency of dairy cattle farms in Konya. The results of the Cobb-Douglas production function revealed that concentrated feed significantly affected the milk production of milk producers who were members of the Milk Producers' Association of Ereğli. Technical efficiency was analysed by using the DEA method. They calculated the technical efficiency of the dairy enterprises as 0.83 for the members of the Association. This score was 0.86 for non-member enterprises.

Sheep breeding farms were vital in the West Mediterranean Region. There was also no

study to examine the efficiency levels of sheep in the region. Therefore, we aimed to measure technical efficiency and to determine inefficiency factors.

3. Material and Method

Data were obtained from sheep farms by using the face to face interview method. Besides, we used the data of TURKSTAT and Sheep and Goat Breeders' Association regarding the presence of small ruminants in the West Mediterranean Region. The data included the 2016 production period. "Neyman Model" which is one of the stratified methods was applied on the population of the research area (Çiçek and Erkan, 1996) and the sample size was found to be 102 for sheep farms.

The West Mediterranean Region, which was determined to be study area consist of Antalya, Isparta and Burdur provinces. We selected fourteen districts which constitute 70% of the sheep assets in these provinces as the research region by using the Purposeful Sampling Method. In this context, Manavgat, Korkuteli, Elmalı, Serik, Kaş districts in Antalya province; Bucak, Merkez, Yeşilova, Tefenni in Burdur province; Yalvaç, Şarkikaraağaç, Merkez, Eğirdir and Senirkent districts in Isparta province constituted the primary population for sheep rearing.

In this study, the efficiency was measured by the Stochastic Frontier Analysis. SFA establishes a relationship between inputs and outputs within the scope of the regression logic (İnan, 2000). SFA method was explained for the production function below in detail (Aigner et al., 1977; Meeusen and Van den Broeck, 1977):

$$Yi = Xi\,\beta + Vi - Ui \qquad (1)$$

In this equation (1), Yi represents the output of 'i' st decision unit, β symbolises the parameters of the (Kx1) dimensional input vector, Xi represents the (K+1) dimensional input line vector. The first element of this vector becomes "1". There are two error terms in the equation: Vi: It represents measurement errors, random factors that are not under the operational control and other inputs that are not involved in the production function. Ui: It is a random variable that is non-negative and represents inefficiency. K is the number of input, X and Y represent inputs and outputs that are stated in the logarithmic method (Coelli, 1996a; Parlakay and Alemdar, 2011; Parlakay et al., 2017).

The technical efficiency that indicated to be TEi was calculated as below:

$$TEi = \exp(-U_i) \qquad (2)$$

After the efficiency scores were calculated in the analysis, these scores were taken to be the dependent variable. Different socio-economic variables were assumed to be

independent variables, and we determined the factors causing inefficiency statistically with the help of regression equations.

Factors that cause inefficiency are identified in efficiency analysis. Inefficiency Factors Model obtains the effects of external factors on productivity. The equation (3) is The Inefficiency Factors Model. 'δ' is the variable coefficient in the vector, and 'Z' is the explanatory external variables vector (Parlakay et al., 2017).

$$Yi = \beta*Xi + Vi - (\delta i * Zi) \quad (3)$$

There were also studies in which parametric and nonparametric techniques were used together. For example; Sharma et al., 1999; Chakraborty et al., 2002; Kwon and Lee, 2004; Johansson, 2005; Ören and Alemdar, 2006; Kaçıra, 2007; Parlakay, 2011; Gözener, 2013; Parlakay et al., 2016.

Considering that the enterprises examined in the region produce under similar conditions in terms of geographical location, agricultural technique and natural factors, technical efficiency was analysed and interpreted. Many computer softwares have been developed to analyse efficiency (Coelli, 1996a; Coelli, 1996b). In this study; Frontier 4.1 software was used for SFA.

In the SFA, which was used to measure the technical efficiency of small ruminant farms in the region, inputs which were used extensively in production and had the most significant impact on efficiency were included. In the efficiency analysis, we used an output the amount of meat per sheep (kg/head) of the meat sold during the years. Roughage feed cost (TRY/head), concentrated feed cost (TRY/head), veterinary cost (TRY/head), marketing cost (TRY/head) and operating capital (TRY/head) were used as inputs.

The variables that caused technical inefficiency were family size (number), frequency of meeting with technical staff (1-I never see, 2-every day, 3-once a week, 4-1-2 times a month, 5-1-2 times a year), feeding system (pasture, feeding + pasture, feeding in the sheep house), additional feeding (1-yes, 0- no), shepherd training status (1-yes, 0- no), farms activity field (goat farms, sheep farms, sheep-goat farms), regular health control (1-yes, 0- no).

In the research, the summary statistics about the variables were presented in Table 1. The average meat yield per sheep which were obtained from the number of sheep remaining in the farms at the end of the year was found to be 18.69 kg. The average roughage feed cost per sheep was 55.24 TRY, the average concentrate feed cost per sheep was 131.38 TRY, the average veterinary cost per sheep was 14.84 TRY, the average marketing cost per sheep was 5.49 TRY and the average operating capital per sheep was found to be 1205.85 TRY.

Table 1: Variables used in efficiency analysis in sheep farms

	Minimum	Maximum	Mean	Standard Deviation
Output				
Meat production (kg / head)	1.00	105.88	18.69	12.64
Inputs				
Roughage feed cost (TRY/head)	9.74	319.07	55.24	42.25
Concentrated feed cost (TRY/head)	19.42	562.79	131.38	93.90
Veterinary cost (TRY/head)	1.19	67.57	14.84	12.84
Marketing cost (TRY/head)	1.00	33.74	5.49	6.85
Operating capital (TRY/head)	501.16	3429.53	1205.85	582.38

1 US dollar = 3.03 TRY (Turkish Liras)

4. Results and Discussion

Since the SFA analysis is output-oriented, output-oriented measurement results were used in this study. It was aimed to determine how much meat production can be increased without making changes in roughage feed cost, concentrate feed cost, veterinary cost, marketing cost and operating capital in sheep breeding.

The average technical efficiency of the farms was determined as 0.77. While the efficiency scores of 2% of the farms were between 0.91-0.99, the efficiency scores of 48% were between 0.81-0.90, the efficiency scores of 35.3% were between 0.71-0.80 and 7.8% of them were between 0.61-0.70. No farm was operated fully effectively (Table 2).

The meat yield can be increased by 16% (1-77/92) according to the SFA method without changing the amount of input used in the enterprises examined. Besides, enterprises that work at minimum levels can increase the amount of meat production by 91% (1-8/92) (Table 2).

Table 2: Technical efficiency of sheep farms

Number of Enterprises (Frequency)		
Technical Efficiencies		
	Frequency	Ratio (%)
<=0.50	6	5.9
0.51- 0.60	1	1.0
0.61- 0.70	8	7.8
0.71- 0.80	36	35.3
0.81- 0.90	49	48.0
0.91-0.99	2	2.0
Total	102	100.0
Summary Statistics		
Minimum	0.08	
Maximum	0.92	
Mean	0.77	

We determined that the correlation between all variables was positive, and the marketing costs and operating capital were weakly correlated with other variables. Also, the correlation between roughage and concentrate feed cost was moderate and significant. The correlation between veterinary cost and roughage cost was found to be weak, and the correlation between concentrate feed was moderate and significant (Table 3).

Table 3: Correlation between independent variables in sheep farms

Variables	Roughage feed cost	Concentrated feed cost	Veterinary cost	Marketing cost	Operating capital
Roughage feed cost	1	.579**	.337**	.012	.235*
Concentrated feed cost	.579**	1	.477**	.127	.064
Veterinary cost	.337**	.477**	1	.046	.102
Marketing cost	.012	.127	.046	1	.054
Operating capital	.235*	.064	.102	.054	1

It is significant at a *0.05; **0.01 significance level

The coefficients of the SFA model calculated for sheep farms were given in Table 4. It was determined that concentrate feed cost, veterinary cost, marketing cost, operating capital usage except for roughage cost had a positive and statistically significant relationship with the amount of meat production per animal. Marketing cost at 10% level, veterinary cost at 5% level were significant. It was determined that concentrate feed cost and operating capital were significant at 1% level. This situation shows that the effect of the expenses made for concentrate feed and the use of operating capital was high in the increase in the total amount of product. In terms of the positive continuation of sheep breeding in the farm, it showed that it was important that the capital and opportunities of the enterprise were adequate and that the sheep were kept in the sheep house and fed more than goat breeding.

In a study on the technical efficiency of sheep dairy industry in Italy, the input cost used in the production process, foreign labour force, capital status, etc. variables were evaluated. It stated that the technical efficiency was 90.5%, and the efficiency differed significantly between private companies and cooperatives (Furesi et al., 2013).

In the technical efficiency study (DEA) in goat breeding in Isparta province; technical efficiency was determined to be 0.44 and 0.66 respectively, according to constant and variable returns. The most important factors affecting efficiency in goat production in the region were farming experience, cooperative membership, milk yield per goat, family and labour force usage (Gül et al., 2016).

Table 4: Most likelihood predictions of coefficients in technical inefficiency model

Variables	Parameter	Coefficient	Standard Deviation	t-ratio	
Stochastic Frontier Analysis					
Invariant	β_0	-0.642	0.956	-0.671	
Ln (Roughage feed cost (TRY/head))	$\beta 1$	-0.091	0.088	-1.037	
Ln (Concentrated feed cost (TRY/head))	$\beta 2$	0.240	0.091	2.635	***
Ln (Veterinary cost (TRY/head))	$\beta 3$	0.139	0.066	2.110	**
Ln (Marketing cost (TRY/head))	β_4	0.080	0.047	1.697	*
Ln (Operating capital ((TRY/head))	$\beta 5$	0.359	0.128	2.802	***
Technical Inefficiency Model					
Invariant	$\delta 0$	-21.158	12.641	-1.674	
Family size (number)	$\delta 1$	0.759	0.476	1.594	
Frequency of meeting with technical staff	$\delta 2$	-0.923	0.560	-1.649	*
Feeding system	$\delta 3$	6.994	3.821	1.831	*
Additional feeding	$\delta 4$	4.434	2.517	1.762	*
Shepherd training status	$\delta 5$	0.012	0.464	0.025	
Farms activity field	$\delta 6$	-3.497	1.923	-1.819	*
Regular health control	$\delta 7$	-1.152	0.717	-1.608	
Variance Parameters					
	$\sigma 2$	3.200	1.765	1.813	*
	γ	0.953	0.031	30.438***	
Log. Likelihood function	-72.82				
LR test	18.12				
Average Technical Efficiency Score	0.77				

It is significant at a *0.1; **0.05; ***0.01 significance level

In the inefficiency model, the frequency of meeting with technical staff, farms activity field and regular health control which were the independent variables in the enterprises affected the ineffectiveness negatively. It was determined that the others affected ineffectiveness positively. In this case, we could said that the increase of contact of the farmers with the technical personnel and the use of their advice, the regular health checks, the following-up of the vaccines and diseases of the sheep in the farm and the farms' activity field positively affected the efficiency in the enterprise (Table 4). Gül et al. (2016) reported that 66% of the breeders were visited by the technical staff in the research of the efficiency on goat enterprises.

It was stated that the frequency of meeting with technical personnel, the feeding system of sheep, the status of additional feeding in the farms and farms activity field were statistically significant at 10% level. We found no statistically significant relationship between other variables with the inefficiencies of the farms.

When the size of the family and shepherd training status in the sheep enterprises were examined, we found a positive correlation between variables and inefficiency. Still, there wasn't statistical significance (Table 4). Wubeneh and Ehui (2006) determined that there was a significant relationship with the literacy at the level of 5% and with animal husbandry

education at the level of 10% in technical inefficiency. Gündüz (2011) found a positive and significant relationship between family size and ineffectiveness in his study in Samsun. He reported that increasing the training level of the farmers would increase technical efficiency.

We determined a statistically significant and positive relationship between feeding system, the status of additional feeding and ineffectiveness (Table 4). So, to decide the feeding system, the amount of additional feeding and additional feeding status according to characteristics of the region and the sheep breeds was a great importance.

Feeding cost was calculated as 21.09% of the total production cost in goat farms of Isparta province. It was determined that grazing-based feeding was used in goat breeding, and given additional feed only for two or three months after birth or during the harsh winter months. Therefore, it was stated that the cost of feeding was low (Gül et al., 2016). Gonçalves et al. (2008) found that positive and negative sign variables were significant on ineffectiveness in the technical inefficiency on feeding calves, and Külekçi and Bayram (2012) found that calves could not benefit from the given feed effectively. They reported that this was an indicator of ineffectiveness of feed utilisation.

Kompas and Che (2004) found that the farm area, which was used by the milking herd, was to be positive and statistically insignificant in the technical inefficiency model in dairy farms in Australia. Also, they determined that the feeding (grain) concentration per cow and the ratio of the irrigated land area were negative and significant. Cabrera et al. (2010) stated that farm efficiency was positively associated with the contribution of the family labour force to farm activities, the use of the total mixed ration feeding system and frequency of milking in their study on dairy farms in Wisconsin.

5. Conclusions and Recommendations

Sheep breeding was mostly done by traditional methods in the West Mediterranean Region. Small family enterprises made up the majority of producers. Production mainly was aimed at producing meat, milk and milk products.

The average efficiency score of the farms was found to be 0.77. According to the results of the research, it was determined that sheep breeders could not use their business resources effectively. For this reason, sheep producers would be able to increase their production and efficiency by using their existing resources better.

It was determined that intensive feeding was done with grazing in the region. Therefore, high input costs affected the productivity of the farmers negatively and decreased

their profitability. So, it would be useful which the Republic of Turkey Ministry of Agriculture and Forestry should receive measures for reducing input costs, mainly feed prices. Besides, it was thought that increasing the support of small ruminant would relieve the producer. Rehabilitation of grazing lands would be useful in terms of better feeding of sheep. Besides, it was necessary to give more training to the farmers about the feeding, diseases and new technologies of sheep to increase the efficiency of the farms. It was thought that improving marketing opportunities for meat, milk and products in the region would also be useful in increasing production and profitability.

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