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TECHNICAL EFFICIENCY OF DAIRY CATTLE FARMS IN THE EASTERN MEDITERRANEAN REGION OF TURKEY BY STOCHASTIC FRONTIER ANALYSIS

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ABSTRACT

The aim of this study was to determine the technical efficiency of dairy cattle farms in Turkey. The main material of the study consists of primary data that were gathered in 2012 from 148 dairy cattle farms in the Eastern Mediterranean Region by the face to face interview method. Data were analyzed using the Stochastic Frontier Analysis method. The effects of socio-economic variables on technical efficiency were calculated using the SFA TE Effects Model. According to research results, the average technical efficiency score was found as 79%. Positive correlation between milk production and the amount of roughage usage, and negative correlation between milk production and labor force usage were found. The socio-economic variables of education, dairy cattle experience and labor force indexes were found positive. However, only dairy cattle experience was found to be significant among these variables. According to the research results, sourcing was found to be sufficient in dairy cattle farms; whereas, efficiency was found insufficient. It is possible to get higher productivity with the same amount of input usage by managing the production process as well.

Key words: Dairy cattle, Technical efficiency, Stochastic Frontier Analysis, TE Effects Model.

INTRODUCTION

Animal breeding is one of the important agricultural activities that take part in the agricultural development of the countries. The animal breeding sector deserves more attention among the other agricultural activities because of not only contribution the animal product, but also creating added value and contributing to employment.

The majority of milk production is acquired from stock farming. According to FAO data, there were 1,426,064,857 cattle in the world by 2013. The three biggest producers in the world were Brazil (211.8 million), India (189 million), and China (113.6 million). In terms of cattle presence France, Germany and England were the leading countries in the EU. Turkey was the 7th in the world and 2nd in the EU for cattle existence (FAO, 2016). The number of cattle in Turkey was around 14.4 million, 42.6% was cross-bred, 43.4% was culture race and 14.0% was native race (TURKSTAT, 2016). The amount of milk production was around 768.6 million tons in the world by 2013, and 635.6 million tons of that was cows' milk. In terms of cow milk production, the US was ranked at the first with 91.3 million tons, and India was number two with 60.6 million tons. Turkey came after New Zealand at number nine with 16.7 million tons, and in the EU, Turkey came after Germany (31.1 million tons) and France (23.7 million tons) (FAO, 2016). In the same year, total amount of milk production in Turkey was 18 million tons and 91% of that was cows' milk (TURKSTAT, 2014).

Every sensible producer aims to gain the most output with current resources, or gain a certain amount of output with minimum resource usage. Fulfilling this goal means that resources need to be used effectively; therefore, determining inefficiency factors in an enterprise and determining usage efficiency of producer resource with current technology are very important (Parlakay and Alemdar, 2011).

In many studies Data Envelopment Analysis, which is one of the non-parametric analyses, was mostly used to measure the efficiency level of dairy cattle farms in Turkey. There are a few studies that used the Stochastic Frontier Analysis. The aim of this inquiry was to measure the technical efficiency of dairy cattle farms, determining inefficiency factors, and offering solutions based on those findings to increase the level of efficiency. In this research, the following studies were utilized; Johansson (2005), Binici *et al.*, (2006) Alemdar and Işık (2008), Theodorodis and Psychoudakis (2008), Cabrera *et al.* (2010), Parlakay and Alemdar (2011), Mor and Sharma (2012), Furesi *et al.* (2013), Al-Sharafat (2013), Balcombe *et al.* (2014), Hazneci and Ceyhan (2015).

MATERIALS AND METHODS

The research area consisted of TR62 and TR63 that included Eastern Mediterranean cities which were determined by the Statistical Regional Unit Classification of Turkey (SRUC, Turkey). These cities were Adana, Osmaniye, Mersin, Hatay and Kahramanmaraş. In 2014, the Mediterranean region held 8.25% (14,223,109 tons) of Turkey's total cattle presence, and 9.10% (16,998,850 tons) total milk production in Turkey. The cities mentioned above retained 60.53% of the cattle presence and 56.19% of the milk production in the Mediterranean region (TURKSTAT, 2016).

The main material of the study consists of data that were collected from dairy cattle farms in Adana, Osmaniye, Mersin, Hatay and Kahramanmaraş in the Mediterranean region by using the face to face interview method. Secondary data consist of Provincial Directorate of Food, Agriculture and Livestock records, Breeding Cattle Raisers Union records, TURKSTAT and FAO statistics. Also, national and international research findings about the topic were utilized. By using the Purposeful Sampling Method, two districts were chosen from each city which had the highest presence milking animal based on the Provincial Directorate of Food, Agriculture and Livestock records (Sarıçam and Ceyhan from Adana, Kadirli and Sumbas from Osmaniye, Tarsus and Mut from Mersin, the city center and Kırıkhan from Hatay, the city center and Andırın from Kahramanmaraş). The number of milking animals in villages within the sampling was determined by the District Directorate of Food, Agriculture and Livestock records and by using the Purposeful Sampling Method. Two villages from each district that represented the research area were chosen considering opinions of the relevant organizations. Dairy cattle farms from 20 villages were itemized by being registered in the TURKVET registration system. In total, 2,559 farms were determined. Sampling size was calculated by using the''Neyman Model'' which is one of the stratified sampling methods (Çiçek and Erkan, 1996), and in this context 148 surveys were carried out.

The Stochastic Frontier Analysis, which is one of the parametric analysis methods to measure the efficiency levels of farms, was used to analyze the data. In the Stochastic Frontier approach, the effects of random factors that are out of the farm control are examined, so two error terms were added to the model. One of the errors includes occasional and random factors that are out of the farm control and has normal distribution and symmetric characteristics. The other one is to take numerical values that are zero or higher than zero, and to represent deviances caused by inefficiency. The Stochastic Frontier Analysis parameters are calculated with the highest probability method. Production function that is used in the Stochastic Frontier Analysis is shown below (Aigner *et al.,* 1977); (Meeusen and van den Broeck, 1977); (Parlakay and Alemdar, 2011):

$$Y_i = X_i \beta + V_i - U_i \qquad (1)$$

In the equation (1), Y_i represents the output of 'i'st decision unit, β represents the parameters of the (Kx1) dimensional input vector, X_i represents the (K+1) dimensional input line vector. The anti-logarithm of (U) represents the technical efficiency of the 'i'st decision unit. K is the number of input, X and Y represent inputs and outputs that are stated in logarithmic form (Coelli, 1996); (Parlakay and Alemdar, 2011).

In the efficiency analysis, it is important to determine the effects of external factors on efficiency. The Inefficiency Factors (TE Effects) Model was used to determine the effects of external factors on efficiency. In this model, efficiency scores and external variables that can cause inefficiency take part together, and production frontier and effects of external factors that can cause inefficiency are examined as a single stage. The Inefficiency Factors Model is obtained in the equation (2) when 'U' that is in the equation (1) is put into the model as a linear function of external variables. In the equation (2), 'Z' is the explanatory external variables vector and 'δ' is the variable coefficient in the vector.

$$Y_i = \beta^* X_i + V_i - (\delta_i^* Z_i) \qquad (2)$$

In the research summary statistics about variables are presented in Table 1. In the Technical Efficiency Analysis, average milk production per cow (kg/year) as output, concentrate feed amount(dry matter) as input (kg/cow), roughage amount as dry matter (kg/cow), veterinary expenses (USD/cow), other variable expenses (USD/year), labor force (hour/cow) and capital expenditure were determined. Frontier 4.1 was used in the analysis.

Factors that have effects on technical efficiency such as farmer's age, level of their education, experience in dairy cattle, rate of family labor in the total labor force, herd size, artificial insemination and milking method were included in the Inefficiency Factors Model. Farmers were coded as follows: farmers with high school or higher degrees 1, others 0; farmers 40 years of age and older 1, others 0; farmers who apply artificial insemination 1, others 0; farmers who milk by machine 1, farmers who milk by hand 0.

Table 1. Summary Statistics about Variables

Variables	Minimum	Maximum	Mean	Standard Deviation
Output				
Annual milk production (kg/cow)	1,470.00	7,500.00	5,075.19	1,176.57
Inputs				
Concentrate feed amount as dry matter (kg/cow)	0.00	9,745.50	2,992.53	1,407.65
Roughage amount as dry matter (kg/cow)	0.00	10,656.00	2,656.07	1,735.67
Veterinary expenses (USD/cow)	0.00	334.73	59.67	43.65
Other variable expenses (USD/year)	2.39	301.26	72.93	44.02
Labor force (hour/cow)	2.53	649.79	103.14	85.61
Capital expenditure (USD/cow)	38.57	845.70	231.55	100.92

RESULTS AND DISCUSSION

In this research, data from farms which make production under similar conditions such as geographical position, natural condition and cultivation techniques were considered. In the Stochastic Frontier Analysis, technical efficiency scores were measured towards output. The purpose of measurement towards output is to determine a possible increase in the amount of output without changing the amount of input. When this is considered from the dairy cattle point of view, the purpose is to determine a possible increase in the amount of milk production without changing the concentrate feed amount, roughage amount, veterinary expenses, labor force or capital costs.

It is known that scores from the Efficiency Analysis are changing between 0 and 1. Scores that approach 1 mean that enterprise resources are used efficiently. While the efficiency limit is considered as 1 in the Data Envelopment Analysis, in the Stochastic Frontier Analysis, it is determined based on production function. So, the highest result is not 1 in the Stochastic Frontier method. The Stochastic Frontier Analysis results are presented in Table 2. According to the analysis results, efficiency scores of enterprises changed between 0.53 and 0.98 and the average efficiency score was found as 0.79. From these evaluations, it is possible to increase milk production by 19% (1-79/98) without changing the amount of input in an enterprise. Also, enterprises which produce at a minimum efficiency level can increase milk production by 46% (1-53/98). Average technical efficiency scores that were calculated by using the SFA in similar previous studies were in Turkey. Hazneci and Ceyhan (2015) found 0.78; Gündüz (2011) found 0.87; in Greece, Theodoridis and Psychoudakis (2008) found 0.81; in the US, Cabrera *et al.* (2010) found 0.88; in India, Mor and Sharma (2012) found 0.79; and in Jordan, Al-Sharafat (2013) found 0.40. The average efficiency score that was obtained from the research was close to scores of the previous studies which were carried out in Turkey and Greece. It was lower than the scores in the US and higher than the scores in the India.

The Ordinary Least Squares Method and the Most Likelihood Method were used to predict the coefficients of the model about the relationship between socio-economic variables and technical efficiency scores. The Most Likelihood Method was chosen as the highest Log likelihood result (26.24). The Most Likelihood results of SFA are presented in table 2.

A positive relationship between milk production and usage of roughage, and a negative relationship between milk production and labor force usage were found. Both parameters were statistically significant. From these data, it could be said that an increase in usage of roughage would also lead to an increase in milk production, and that an increase in the labor force would not increase milk production. Because they were not statistically significant, the amount of concentrate feed usage, veterinary costs, other variable costs and capital costs were not commented on. γ Parameter was calculated as 0.59 and it was statistically significant. This value means that 59% of the variation in milk production was caused by technical inefficiency. In another study, Binici *et al.* (2006) found a positive relationship between milk production per cow and concentrate feed usage, roughage usage, labor force usage and capital. All the inputs except for roughage were statistically significant.

Hypothesis tests for technical efficiency coefficients are presented in Table 3. The first ‘zero hypothesis’ was declined. So, the inefficiency model that was for production function did not have sufficient representation capability for the data that were examined. The LR (likelihood ratio) score was found as 26.24 from the result of the null analysis about production function that excludes inefficiency variables. According to the chi square table, this result was statistically significant at 5% level. Age, herd size, artificial insemination and milking method which are socio-economic variables had negative coefficients. Negative coefficients mean that farmers who were 40 years of age and older, had a larger herd size, applied artificial insemination and being milked by machine were more efficient. However, these variables were not statistically significant.

Education level and dairy cattle experience, which are socio-economic variables, and family labor force ratio had positive coefficients. A positive coefficient means that farmers with a high school or higher level of education, an increase in their dairy cattle experience and an increase in the family labor ratio in the labor force cause an increase in inefficiency. However, among these variables only dairy cattle experience was statistically significant. In the study, only formal education (elementary school, middle school, high school etc.) was taken into consideration. Since formal education does not include vocational education, the level of education has limited influence on craft knowledge and occupational ability. In the event of supporting formal education with informal education (technical courses, workshops, etc.), the effect of education level on efficiency could be changed positively. Farmers with a high education level are expected to perform well, be able to use agricultural technologies and modern production techniques better and sell their products for a higher price. Moreover, educated farmers could be more open minded to agricultural extension specialists' advice, and it is possible to carry out more productive production by using inputs efficiently (Al-sharafat, 2013); (Abdul-Rahaman, 2016).

Table 2. Most Likelihood Predictions of Coefficients in Technical Inefficiency Model

Variables	Parameter	Coefficient	Standard Deviation	t-ratio
Stochastic Frontier Analysis				
Invariant	β_0	8.477***	0.440	19.260
Ln (Concentrate feed)	β_1	-0.005	0.014	-0.329
Ln (Roughage)	β_2	0.023*	0.012	1.972
Ln (Veterinary)	β_3	0.007	0.012	0.618
Ln (Other variable cost)	β_4	0.035	0.043	0.825
Ln (Labor)	β_5	-0.090***	0.031	-2.910
Ln (Capital cost)	β_6	0.032	0.053	0.598
Technical Inefficiency Model				
Invariant	δ_0	0.529**	0.231	2.294
Age	δ_1	-0.115	0.096	-1.197
Ln(Education)	δ_2	0.005	0.113	0.048
Herd size	δ_3	-0.088	0.063	-1.400
Artificial insemination	δ_4	-0.048	0.130	-0.372
Milking method	δ_5	-0.100	0.099	-1.018
Experience	δ_6	0.007**	0.003	2.226
Ln (family labor force ratio)	δ_7	0.229	0.244	0.940
Variance Parameters				
	γ	0.594***	0.190	3.127
	σ^2	0.067***	0.018	3.834
Log. likelihood function		13.22		
LR test		26.24		
Average Technical Efficiency Score		0.79		
Minimum Technical Efficiency Score		0.53		
Maximum Technical Efficiency Score		0.98		

It is significant at a *0.1; **0.05; ***0.001 significance level

In this study, factors that cause inefficiency were aimed at being determined by measuring the technical efficiencies of dairy cattle farms in the East Mediterranean Region of Turkey. There are recommendations to improve efficiency based on research findings.

According to the research results, despite producing under similar circumstances and using the same inputs, there are farms in the east Mediterranean region that cannot use their resources efficiently due to different applications. According to the average technical efficiency score, it could be said that dairy cattle farms in Turkey are using their resources well but not efficiently enough. Farmers could increase their efficiency and productivity by managing the production process better. They should be supported about issues they are insufficient by members of the Ministry of Food, Agriculture and Livestock. Also, education and agricultural extension services should be provided by the producer unions. Farmers who have low efficiency scores could be supported by providing technical training to manage the production process better.

The research findings indicate that increasing the amount of roughage will lead to an increase in milk production. Contrary to this, increasing the labor force will cause a decrease in milk production.

Due to an assumption of the effects on efficiency scores, some variables such as age, education level, herd size, artificial insemination, milking method, dairy cattle experience and family labor ratio in the labor force were included in the model. It was found that farmers who were 40 years of age and older, had a larger herd size, applied artificial insemination, and being milked by machine were more efficient.

Table 3. Hypothesis Tests of Technical Efficiency Coefficients

Variables	Zero Hypothesis	Log Likelihood	t statistics (λ)	Critical value	Decision
Constant : δ_0	H_0: γ :δ_0 =...=δ_7= 0	13.22	26.24	16.92[a]	H_o: Declined
Age : δ_1	H_1:δ_1 = 0	12.24	1.97	3.84[b]	H_1: Accepted
Ln(Education) : δ_2	H_2:δ_2= 0	13.22	0.01	3.84[b]	H_2: Accepted
Herd size : δ_3	H_3:δ_3= 0	11.79	2.86	3.84[b]	H_3: Accepted
Artificial insemination: δ_4	H_4:δ_4= 0	13,15	0.14	3.84[b]	H_4: Accepted
Milking method: δ_5	H_5:δ_5= 0	12.56	1.32	3.84[b]	H_5: Accepted
Experience : δ_6	H_6:δ_6= 0	9.92	6.60	3.84[b]	H_6: Declined
Ln (Family labor ratio) : δ_7	H_7:δ_7= 0	11.27	3.90	3.84[b]	H_7: Declined

a; Degrees of freedom: 9; b; Degrees of freedom: 1; (at 0.05 significance level)

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