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TECHNICAL EFFICIENCY OF SHEEP FARMING IN TURKEY: A CASE STUDY OF ISPARTA PROVINCE

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Abstract

The purpose of the study was to analyze the technical efficiency of sheep farming using Data Envelopment Analysis (DEA) in Isparta province in Turkey. The data used were collected from 80 farmers using the stratified sampling method by means of a questionnaire. The technical efficiency of the sheep farming varied between 0.63 and 1.00. The mean efficiency of farms was calculated to be 0.41 and 0.48 for constant and variable returns to scale assumptions, respectively. The greatest slacks were defined as veterinary-drug costs and labour use. The most significant factors affecting efficiency of sheep farming were education, family and hired labour, AU, milk yield per sheep, age at separation (years) and number of lambs per sheep born (%).

Key words**:** *sheep farms, technical efficiency, data envelopment analysis*

INTRODUCTION

Livestock activities are important for balancing of the workforce and better usage of main and by-products obtained with plant production. In addition, livestock activities provide optimal resource utilization and have a positive impact on farm income [13]. Animal husbandry has an important function in rural and economic development as well as in balanced and healthy nutrition [4]. Sheep breeding takes an important place among animal production activities in the world. Forage and pastures that are not used for other purposes can be evaluated through sheep production activity. The sheep transform the natural vegetation in such areas to food such as meat and milk to feed people. Sheep benefit more poor forage than other farm animals. Sheep also produce wool and leather products such as those used in making clothing items for people's lives [14].
One of the major problems of the sheep farms in Turkey is that they are usually small family farms. This situation affects the supply of inputs and the use of technology negatively. However, there are also advantages such as small-scale enterprises can deal with the production process more closely. Nowadays Determination and comparison of the farm performance become more important. The most appropriate method for this comparison is to determine the efficiency score [28].
The efficiency is defined as the degree of reaching the targets and the relationship between the desired goal and the actual goal. It is important to distinguish between the results and the outputs while focusing on the efficiency. Measuring and evaluating results is more difficult than evaluating the input or output [19]. The efficiency allows determining where the company is situated in the current competitive market and shows how well the output can be obtained from the available inputs [36].
There have been many studies on animal production related to Data Envelopment Analysis. Toro-Mujica et al., (2011) [34] were analysed production processes and economic viability of farms in a traditional dairy sheep farming community of Spain (Castilla-La Mancha), and modelled their production and quantifying their technical efficiency. Theocharopoulos et al., (2007) [32] used data envelopment analysis to determine the effectiveness of sheep breeding enterprises in

Greece. Theodoridis et al., (2012) [33] used the data envelope analysis to determine the technical efficiency of Sakız sheep farming in Greece. Many studies related to the efficiency levels of dairy farms in Turkey has also done [20, 23, 3, 24, 6, 7, 17, 25, 5, 29, 26, 28]. Özden and Armağan (2014) [27] used data envelopment analysis to determine the efficiency of beef cattle farms. Şanal and Işık (2014) [30] used data envelopment analysis to determine the efficiency of bovine farms in Erzurum province. Gul et al. (2016) [18] used data envelope analysis to determine the technical efficiency of goat farms in Isparta.

Thanks to Turkey's geographical structure and the wide pastures are thought to have significant potential for sheep breeding. Recently, in Turkey and in the Isparta the presence of sheep appears to be significantly increased. Sheep number in Turkey is approximately 23.1 million head in 2010 and reached 33.7 million in 2017, with an increase of 46%. Isparta Province shows a 129% increase in the same period and reached 229 thousand sheep.

In this study, it is aimed to determine the technical efficiency of sheep farms in Isparta province. Data envelopment analysis, which is a non-parametric method, has been used for the technical efficiency. Tobit Regression Analysis investigated the relationship between the technical efficiency coefficients obtained from the DEA and the selected socio-economic variables in order to determine the factors causing the inefficiency. It is hoped that this study will provide useful data to sheep producers, policy makers and researchers working on this issue.

MATERIALS AND METHODS

The main material of the study is obtained by using the questionnaire from the sheep farms in Isparta. It has also benefited from similar work carried out by various individuals and organizations. Survey data cover the production period of 2017.

According to the information obtained from Isparta Province Sheep & Goat Breeders Association, the districts of Centre, Yalvaç, and Şarkikaraağaç, are dominant in sheep breeding, so these districts were selected. All the sheep farms in these districts are constituted the research population. According to TUİK data, the selected districts constitute approximately 67% of total sheep in Isparta province. For this reason, it can be said that the research region has the qualifications to represent the sheep farming in Isparta Province.

The number of samples representing the population was calculated as 80 by using the Neyman method [35]. The distribution of selected enterprises by groups is given in Table 1.

Table 1. Distribution of sheep farms according to the animal numbers

Animal number	Farm number	Percentage (%)
≤100	23	28.75
101-200	22	27.50
201+	35	43.75
Total	80	100.00

Source: Own calculation

Efficiency analysis

Efficiency is a concept that refers to the proper use of resources without waste. Technical efficiency is defined using the input component in the most appropriate way and the most successful output level [31].

In order to identify technically active unit among the examined farms, technical efficiency was calculated using Data Envelopment Analysis (DEA) method. DEA is a technique based on linear programming principles and designed to measure the relative effectiveness of farm or economic organizations for transforming input into the output referred to as "Decision-making Units" in the literature [12]. The Data Envelopment Analysis (DEA) does not impose any functional form and can handle easily multiple input and multiple output cases. Moreover, in DEA applications inputs and outputs can have very different units of measurement without requiring any a priori trade-offs or any input and output prices. These highly desirable features provide this analysis become popular among researchers [16].

Coelli et al., (1998) [11] explained efficiency in two main ways. These are input-oriented

and output-oriented criteria. The input-oriented model of the Banker Charnes Cooper (BCC) for decision-making units that produce M output using K inputs with different inputs is given below: [11, 12].

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

$$-y\ i + Y\lambda \geq 0$$
$$\theta\ xi - X\lambda \geq 0$$
$$N1\ '\lambda = 1$$
$$\lambda \geq 0$$

Where θ is a scalar value, N1' is the constraint for the convexity condition, and λ is an N x 1-dimensional vector. Y is the output matrix; X represents the input matrix. The efficiency scores of the farms are indicated by θ, which takes a value between zero and one. This linear programming model needs to be solved for each farm separately. θ value will be the efficiency score for the farm i. This linear programming problem must be solved separately for each farm in the research sample. According to Farrell's (1957) [15] definition, the θ value indicates that it is technically efficient. Coelli et al., (1998) [11] and Coelli (1996; 1997) [9, 10] developed a computer program that implements a robust multi-stage model among multi-stage methodology and other options.

In this study, four input and one output models have emerged. In the analysis, gross production value (GPV) per bovine unit output was used. Milk and dairy products, wool, fertilizer and productive value increases were taken into account in the calculation of GPV. The inputs used in the analysis are; labour force (hour / AU), concentrate feed (kg / AU), roughage (kg / AU) and veterinary-drug costs (TL / AU). The labour input consists of the sum of foreign and family labour hours per cattle unit.

RESULTS AND DISCUSSIONS

General information on interviewed sheep farms is given in Table 2. The average age of sheep breeders was 47.54 years, and their education duration was 5.80 years and their experience was 23.05 years in sheep farming. In a similar study by Gül et al. (2016) [18], the average age of the breeders was determined as 50.51 years, their education level as 5.18 years and their experience in goat breeding as 25.33 years.

The average sheep stock in the farms was found 183.49 heads (17.58 AU). The milk yield per sheep was calculated at 0.44 liters/day and the average lactation period was indicated 96.38 days. The grazing duration of the cows were found to be 242 days per year. In a study conducted in Konya province, it was determined that the average grazing time of sheep was 240 days [1].

The average planting area per farm is 5.02 hectares. The average planting area of the forage crops was 4.64 hectare, it was determined that 35.68% consisted of barley, 27.60% wheat, and 13.93% vetch. Feed plants constitute 92.32% of the total processed area. It was determined that 27.50% of the producers surveyed used credits for sheep farming. 40 per cent of the breeders use credits from cooperatives and 93.75 per cent from Breeding Sheep-Goat Breeders Association.

Table 2. General features of sheep breeding farms

Features	Mean
Breeders age (year)	47.54
Breeders education level (year)	5.80
Breeders experience (year)	23.05
Sheep (head)	183.49
Sheep (AU)	17.58
Milk yield (lt/sheep/ day)	0.44
Lactation duration (day)	96.38
Grazing duration (day)	242
Planted area (ha)	5.02
Forage crops area (ha)	4.64
Credit usage rate (%)	27.50
Cooperative membership (%)	40.00
Breeding Sheep-Goat Breeders Association membership (%)	93.75

Source: Own calculation

Statistical data on the variables used in the Data Envelopment Analysis is given in Table 3. The highest variability observed in the chart is observed in 51.39% roughage intake followed by 42.61% workforce, 41.85% veterinary-drug expenditures and 24.47% concentrated feed intake. Gül et al. (2016) [18] determined that inputs showing the

highest variability in goat breeding farms in Isparta province are labour (hr / AU), concentrate feed (kg / AU) and roughage (kg / AU).

Table 3. Descriptive statistics of DEA variables

Variables	Min	Max	Mean	Std. Ev.	Variation coefficient (%)
Output					
GPV/AU	5177.23	10670.73	7178.30	1160.96	16.17
Input					
Labour(hour/AU)	150.39	912.04	326.65	139.19	42.61
Concentrated feed(kg/AU)	361.27	1936.38	1078.81	264.03	24.47
Roughage(kg/AU)	260.15	4865.13	1170.14	601.34	51.39
Veterinary and drug expenses/AU	113.12	613.50	302.03	126.41	41.85

Source: Own calculation

The purpose of the input-oriented data envelopment analysis is; the amount of input used can be reduced proportionally without producing a change for output produced. The results of the analysis for the input are given in Table 4. As seen in the table, it was found that out of 80 sheep farms, except for 5 farms (6.25%), the scale was below constant return to scale and 13 farms (16.25%) were below the variable return to the scale. The technical efficiency scores of the sheep farms range from 0.48 to 1.00. The average efficiency score of researched farms was calculated as 0.69 under the assumption of fixed return on the scale and 0.79 under the assumption of the variable return to scale. In this case, it may be the case that sheep farms reduce their inputs by 21% without changing the output amount. Among the 13 efficient sheep farms, 2 of them are found in-group 1, one is in the group 2 and 10 farms are in the group 3. The average activity of sheep farms in Greece by Theocharopoulos et al. (2007) [32] was 0.54 under the assumption of the constant return to scale and 0.66 under the variable return assumption. In this case, it was stated that it might be the case that the enterprises should reduce the inputs by 24% while keeping the output amount.

In a study conducted by Gül et al. (2016) [18], the average activity of goat breeding farms was calculated as 0.44 under the assumption of the constant return to scale and 0.66 under the variable return to scale assumption. It has been found that sheep farms need to reduce their inputs by 34% without reducing the amount of output.

Table 4. Input- oriented efficiency score results

Efficiency score	CRS	VRS	SE
1.00	5	13	5
0.91-0.99	6	6	29
0.81-0.90	9	22	22
0.71-0.80	16	15	19
0.61-0.70	17	15	5
0.51-0.60	16	7	0
0.41-0.50	11	2	0
Min	0.41	0.48	0.63
Max	1.00	1.00	1.00
Mean	0.69	0.79	0.87

Source: Own calculation

Input losses and excessive input usage

The input losses due to the inefficiency of sheep farms were calculated by subtracting the targeted input usage amounts from the use of existing inputs of the farms, which did not provide efficiency in the production, in order to realize an effective production activity. In other words, the surplus labour, concentrate feed, roughage and veterinary-drug expenditures of the ineffective farms in each group are determined according to the reference farms. It has been found that 25 of the 80 sheep farms use 7.64% surplus labour, 15 sheep farms use 3.68% surplus concentrated feed, 8 of the sheep farms use 2.19% surplus roughage and 26 of the sheep farms spend 8.78% surplus for the veterinary and drugs (Table 5). In a study conducted by Gül et al. (2016) [18] in Isparta province, it was found that that 44 of the 92 goat farms use 23.59% surplus labour, 60 goat farms use 28.85% surplus concentrated feed, 26 of the goat farms use 15.58% surplus roughage and 30 of the goat farms spend 21.26% surplus for the veterinary and drugs.

Determination of causes of technical inefficiency

The relationship between efficiency scores and selected socio-economic variables was investigated by Tobit regression in order to determine the factors causing ineffectiveness. In the analysis of Tobit, the variables such as education level, total labour hour, number of sheep as AU, milk yield (lt / sheep / day), age at which sheep were separated from the right side (years) and number of lambs per breeding sheep the effects on the technical efficiency levels of the enterprises have been examined. The coefficients obtained with the Tobit regression are given in Table 6 together with the standard error and p values.

The educational status of the breeders is represented by a dummy variable. Number 1 represented those with a level of education of 8 years and over and the others were represented by number 0. Findings show that as the education level increases, the effectiveness of farm increases and it is statistically significant ($p < 0.05$). However, some researchers have stated that there is a negative relationship between educational level and effectiveness [21, 2, 8, 22, 29]. Gül et al. (2016) [18] found that there was a positive relationship between the level of education and efficiency in their study. However, this was not statistically significant ($p > 0.10$).

The labour was represented by the total annual time of the family and foreign labour. According to the results of the regression, the decrease of the coefficient shows that the efficiency decreases with increasing the labour utilization and this result is statistically significant ($p < 0.01$). (Gül et al., 2016) [18], there was a negative relationship between the labour and the efficiency and statistically significant ($p < 0.01$).

According to the obtained results, sheep number as animal unit affects the efficiency of the farms and this was found statistically significant ($p < 0.01$). Another result of the research is that the milk yield (lt / sheep/day) increases the efficiency of the farm and this result is statistically significant ($p < 0.10$). Gül et al. (2016) [18] found that there was a positive relationship between milk yield per goat and efficiency of the farm and their finding was statistically significant ($p < 0.01$).

Milking duration / separation from the milking of the sheep was included as a year to the model. The results showed that the efficiency decreased with increasing the age of separation from the milking, and this result was statistically significant ($p < 0.01$). Regression analysis results showed that the efficiency increased as the calving rate per sheep (%) increased, and this finding was statistically significant ($p < 0.01$).

Table 5. Input losses and excessive usage

Input	Number of farms	Average input losses	Average input usage	Excessive input usage (%)
Labour (hour/AU)	25	25.05	326.65	7.64
Concentrated feed (kg/ AU)	15	39.74	1,078.81	3.68
Roughage (kg/ AU)	8	25.60	1,170.14	2.19
Veterinary and drug expenses (TL/ AU)	26	26.52	302.03	8.78

Source: Own calculation

Table 6. Results of Tobit regression analysis

Variable	Coefficient	Std. Error	z-value	p-value
Constant	0.255379	0.170879	1.494500	0.1350
Education	0.058504	0.028101	2.081925	0.0373*
Labour	-6.758645	1.480359	-4.565543	0.0000***
AU	0.019677	0.002444	8.051922	0.0000***
Milk yield (lt/sheep/day)	0.279166	0.147005	1.899026	0.0576*
Milking duration / separation from the milking (year)	-0.050281	0.018177	-2.766175	0.0057***
The calving rate per sheep (%)	0.005679	0.001030	5.512388	0.0000***

Source: Own calculation

CONCLUSIONS

It was found that out of 80 sheep farms, except for 5 farms (6.25%), the scale was below constant return to scale and 13 farms (16.25%) were below the variable return to the scale. The technical efficiency scores of the sheep farms range from 0.48 to 1.00. The average efficiency score of researched farms was calculated as 0.69 under the assumption of fixed return on the scale and 0.79 under the assumption of the variable return to scale. In this case, it may be the case that sheep farms reduce their inputs by 21% without changing the output amount.

It has been found that approximately 31 % of the sheep farms use 7.64% surplus labour, 19% of the sheep farms use 3.68% surplus concentrated feed, 10% of the sheep farms use 2.19% surplus roughage and 33% of the sheep farms spend 8.78% surplus for the veterinary and drugs. Especially veterinary-drug expenditures and labour costs are drawing attention in the input losses. It is suggested for breeders to take collective services by combining with other farms instead of receiving individual veterinary services that in order to reduce the veterinary-drug costs. The need for an active producer organization is better understood when farms are in small-scale. It is recommended that more technological improvements are needed to optimize the use of the family labour or foreign labour.

According to Tobit regression analysis, the education level ($p < 0.05$), total labour hours ($p < 0.01$), number of sheep in terms of AU ($p < 0.01$), milk yield (lt / sheep / day) 0.10), milking duration / separation from the milking (year) ($p < 0.01$) and the calving rate per sheep (%) ($p < 0.01$) affect the efficiency of the farms and these were found statistically significant. It was found that the training levels of producers should have a positive effect on the farm efficiency. Therefore, it has concluded that training and extension services are important. Keeping high yielding breeds of sheep in farms appropriate to the regional conditions will also increase the efficiency levels.

REFERENCES

[1]Aktaş, A., 2009, Konya ili Karapınar ilçesi koyunculuk işletmelerinin ekonomik analizi. Yüksek lisans tezi, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, 89 sayfa, (Economic analysis of sheep farms in Karapinar district of Konya. Master's thesis, Selcuk University, Institute of Science, 89 pages), Konya.

[2]Alemdar, T., Ören, M. N., 2006, Determinants of technical efficiency of wheat farming in Southeastern Anatolia, Turkey: a nonparametric technical efficiency analysis. Journal of Applied Sciences 6: 827-830.

[3]Armağan, G., Nizam, S., 2012. Productivity and Efficiency Scores of Dairy Farms: The Case of Turkey. Qual Quant, 46: 351–358.

[4]Aslan, S., Bozdoğan, Ş., Uzun, T., Gökmen, C., 2001, Tarım Sektöründe Hayvancılık ve 50. Yılında EBK. Et Balık Kurumu Ürünleri A.Ş. Genel Müdürlüğü, (Livestock in Agricultural Sector and EBK at 50th Year. Meat Fish Kurumu Ürünleri A.Ş. General Directorate), Ankara.

[5]Aydın, E., Yeşilyurt, C., Sakarya, E., 2014, Measuring the Performance of Cattle Fattening Enterprises with Data Envelopment Analysis: Comparative Analysis of Enterprises in the Northeast Anatolia Region (TRA) Between the Years 2009-2010. Kafkas Üniversitesi Veteriner Fakültesi Dergisi, 20(5), 719-725.

[6]Binici, T., Zualuf, C.R., Özel, R., Sevinç, R., Işgın, T., 2013a, Assessing Production Efficiency of Dairy Farms in Şanlıurfa Province, Turkey. Journal of Animal and Veterinary Advances, 12(5), 621-624.

[7]Binici, T., Demircan, V., Yılmaz, H., Gül, M., Bal, T., 2013b, Assessing Production Efficiency of Laying Hens Farms in Afyon Province, Turkey. Journal of Animal and Veterinary Advances, 12(18), 1473-1477.

[8]Cinemre, H. A., Ceyhan, V., Bozoğlu, M., Demiryürek, K., Kılıç, O., 2006, The cost efficiency of trout farms in the Black Sea Region, Turkey. Aquaculture 251: 324-332.

[9]Coelli, T. J., 1996, A guide to DEAP Version 2.1: a data envelopment analysis (computer) program. CEPA Working Paper 96/08. Department of Econometrics, University of New England, Armidale, Australia.

[10]Coelli, T. J., 1997, A multi stage methodology for the solution of orientated DEA models. Paper presented to the Taipei International Conference on Efficiency and Productivity Growth, Taipei.

[11]Coelli, T. J., Rao, D. S. P., Battese, G. E., 1998, An introduction to efficiency and productivity analysis. Kluwer Academic Publishers, Boston.

[12]Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., Battese, G. E., 2005, An introduction to efficiency and productivity analysis. 2nd ed. Springer Science+Business Media, Inc., New York, USA.

[13]Dağıstan, E., Koç, B., Gül, A., Gül, M., 2008, Koyunculuk üretim faaliyetinin faktör analizi: Orta-Güney Anadolu örneği, YYU Ziraat Fakültesi Tarım Bilimleri Dergisi, (Factor analysis of sheep breeding production activity: Central-South Anatolian example,

YYU Agricultural Faculty Journal of Agricultural Sciences), 18 (2): 67-77.
[14]Emsen, H., Yaprak M., Emsen, E., Köyceğiz, F., 2008, Romanov koyununun Erzurum şartlarına adaptasyonu Projesi. (Project of adaptation of Romanov sheep to Erzurum conditions), http://www.erzurumtb.org.tr/, Accesed July 5, 2018.
[15]Farrell, M. J., 1957, The measurement of productive efficiency. Journal of the Royal Statistical Society Series A, III, 120: 253-290.
[16]Fousekis, P., Spathis, P., Tsimboukas, K., 2001, Assessing the Efficiency of Sheep Farming in Mountainous Areas of Greece. A non-Parametric Approach. Agricultural Econometric Review, August 2001, Vol 2, no.2: 5-15.
[17]Gözener, B., 2013, TR83 Bölgesinde Sığır Yetiştiriciliğine Yer Veren İşletmelerin Ekonomik Analizi ve Teknik Etkinlik. Gaziosmanpaşa Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi, 157s, Tokat (Economic Analysis and Technical Efficiency of Cattle Breeding Farms in the. Gaziosmanpaşa University, Institute of Science, PhD Thesis, 157 pag., Tokat)
[18]Gül, M., Demircan, V., Yılmaz, H., Yılmaz, H., 2016, Technical Efficiency of Goat Farming in Turkey: A Case Study of Isparta Province. Revista Brasileira de Zootecnia, 45(6), 328-335.
[19]Gülcü, A., Coşkun, A., Yeşilyurt, C., Coşkun, S. ve Esener, T., 2004, Cumhuriyet Üniversitesi Diş Hekimliği Fakültesi'nin Veri Zarflama Analizi Yöntemiyle Göreceli Etkinlik Analizi, Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi, Cilt: 5, Sayı: 2, ss. 87-104 (Relative Efficiency Analysis of Cumhuriyet University Dentistry Faculty by Data Envelopment Analysis, Cumhuriyet University, Journal of Economics and Administrative Sciences, Vol: 5, No: 2, pp. 87-104)
[20]Gündüz, O., 2011, Süt Sığırcılığında Teknik Etkinlik: Stokastik Etkinlik Sınırı Yaklaşımı. Harran Üniversitesi, Ziraat Fakültesi Dergisi, (Technical Efficiency in Dairy Cattle: Stochastic Efficiency Limit Approach. Harran University, Journal of Agricultural Faculty), 15(1), 11-20.
[21]Kaliba, A. R., Engle, R. C., 2004, Cost efficiency of catfish farms in Chicot County, Arkansas: the impact of extension purposes. Selected paper prepared for presenting at the Southern Agricultural Economics Association Annual Meeting, Tulsa, Oklahoma. 25p.
[22]Koç, B., Gül, M. ve Parlakay, O., 2011, Determination of technical efficiency in second crop maize growing farms in Turkey: A case study for the East Mediterranean in Turkey. Asian Journal of Animal and Veterinary Advances 6:488-498.
[23]Koyubenbe, N., Özden, A., 2011, Süt Sığırcılığı İşletmelerinde Parametrik Etkinlik Ölçümü: İzmir İli Örneği. Adnan Menderes Üniversitesi, Ziraat Fakültesi Dergisi, (Parametric Efficiency Measurement in Dairy Cattle Enterprises: Example of İzmir Province. Adnan Menderes University, Journal of Agricultural Faculty), 8(2), 23-27.
[24]Külekçi, M., Bayram, B., 2012, Buzağıların Beslenmelerinde Etkinliğin Belirlenmesi: Stokastik Sınır Analizi Uygulaması. Harran Üniversitesi, Ziraat Fakültesi Dergisi, (Determination of Effectiveness in Feeding of Ice: Application of Stokastic Boundary Analysis. Harran University, Journal of Agricultural Faculty), 16(1), 55-61.
[25]Külekçi, M., 2013, Süt Sığırcılığı İşletmelerinde Etkinlik Analizi: Erzurum İli Örneği. Atatürk Üniversitesi, Ziraat Fakültesi Dergisi, (Efficiency Analysis in Dairy Cattle Enterprises: The Case of Erzurum Province. Ataturk University, Journal of Agricultural Faculty), 44(2), 103-109.
[26]Oğuz, C., Canan, S., 2016, Factors Affecting Milk Production in Dairy Farming Enterprises and Effectiveness Analysis: A Case Study in Konya Province of Turkey. Custos e @gronegócio on line, 12(3), 121-136.
[27]Özden, A., Armağan, G., 2014, Efficiency Analysis on Cattle Fattening in Turkey. Veterinarija ir Zootechnika, 67(89): 88-93.
[28]Özden, A., 2016, Veri Zarflama Analizi ile Süt Sığırcılığı İşletmelerinin Performans Düzeylerinin Belirlenmesi. Tarım Ekonomisi Dergisi, (Determination of Performance Levels of Dairy Cattle Enterprises by Data Envelopment Analysis. Journal of Agricultural Economics), 22(1): 49-55.
[29]Parlakay, O., Semerci, A., Çelik, A. D., 2015, Estimating technical efficiency of dairy farms in Turkey: a case study of Hatay Province. Custos e Agronegócio Online 11: 106-115.
[30]Şanal, A., Işık, H.B., 2014, Erzurum İli Büyükbaş Hayvancılık İşletmelerinin Etkinlik Analizi. XI. Tarım Ekonomisi Kongresi, 3-5 Eylül, Samsun, (Activity Analysis of Cattle Livestock Establishments in Erzurum Province. XI. Agricultural Economics Congress, 3-5 September, Samsun), 1105-1112.
[31]Tarım, A., 2001, Veri Zarflama Analizi: Matematiksel Programlama Tabanlı Göreli Etkinlik Ölçüm Yaklaşımı. Sayıştay Yayın İşleri Müdürlüğü, Araştırma, İnceleme, Çeviri Dizisi: 15, Ankara (Data Envelopment Analysis: Mathematical Programming Based Relative Efficiency Measurement Approach. Turkish Court of Accounts Publication Directorate, Research, Review, Translation Series: 15, Ankara).
[32]Theocharopoulos, A., Melfou, K., Papanagıotou, E., 2007, A microeconomic approach for agricoltural development: a dea application to greek sheep farms. New Medit N. 4: 48-53
[33]Theodoridisa, A., Ragkosb, A., Roustemisc, D., Galanopoulosc, K., Abasc, Z., Sinapisd, E., 2012, Assessing technical efficiency of Chios sheep farms with data envelopment analysis. Small Ruminant Research, 107: 85– 91
[34]Toro-Mujica, P., García, A., Gómez-Castr, A.G., Acero, R., Perea, J., Rodríguez-Estévez, V., Aguilar, C., Veraa, R., 2011, Technical efficiency and viability of organic dairy sheep farming systems in a traditional area for sheep production in Spain. Small Ruminant Research 100 (2011) 89–95.

[35]Yamane, T., 2001, Basic Sampling Methods. Translators: A. Esin, M.A. Bakır, C. Aydın, E.Gürbüzsel, Publishing of Literatür, No: 53, ISBN: 975–8431–34-X, İstanbul.
[36]Yolalan, R., 1993, İşletmelerarası Göreli Etkinlik Ölçümü, Ankara, MPM Yayınları No: 483 (Occupational Relative Efficiency Measurement, Ankara, MPM Publications No: 483)