2025 SCIENCELINE

Online Journal of Animal and Feed Research

Volume 15, Issue 2: 89-97; March 30, 2025

ISSN 2228-7701

DOI: https://dx.doi.org/10.51227/ojafr.2025.11

EVALUATION of ECONOMIC EFFICIENCY of SHEEP FARMING ENTERPRISES in KARS PROVINCE by DATA ENVELOPMENT ANALYSIS

Mehmet KÜÇÜKOFLAZ[1]✉, Erol AYDIN[1], Can İsmail ZAMAN[1], Merve AYYILDIZ AKIN[2], Savaş SARIÖZKAN[3], Aleyna Kübra AYDIN[1]

[1]*Kafkas University, Faculty of Veterinary Medicine, Department of Animal Health Economics and Management, Kars 36000, Turkey*
[2]*Kafkas University, Faculty of Veterinary Medicine, Department of Biostatistics, Kars 36000, Turkey*
[3]*Erciyes University, Faculty of Veterinary Medicine, Department of Animal Health Economics and Management, Kayseri 38000, Turkey*

✉Email: mehmetoflaz38@gmail.com

Supporting Information

RESEARCH ARTICLE

PII: S2228770125000011-15

Received: February 03, 2024

Revised: March 25, 2025

Accepted: March 27, 2025

ABSTRACT: In this study, it was aimed to determine the economic activities of sheep farming enterprises in Kars province, Turkey by Data Envelopment Analysis (DEA). For this purpose, data obtained from face-to-face surveys conducted on 99 sheep farming enterprises in Kars Province were used. In the DEA applied to determine the economic efficiency of sheep enterprises, the Charnes Cooper Rhodes (CCR) was used according to the input-oriented scale. According to the study findings, the average age of the owners of the enterprises, all of whom were male, was 46 years, and their experience was average 9 years. It was determined that the majority of the farm owners (76.8%) were primary and secondary school graduates. It was determined that 67.7% of the enterprises were farming only Akkaraman, 3% were farming only Morkaraman, and 29.3% were farming both of the breeds. According to the DEA results used to determine the economic efficiency of enterprises, 41 enterprises (41.4%) were determined to be effective and 58 (58.6%) were determined to be inefficient. Consequently, it was concluded that inefficient enterprises need to reduce their input costs to become economically effective. In addition, it has been considered that it is very important for enterprises to make progress in the stages of obtaining, processing, branding and marketing high value-added products (milk/dairy products and meat/meat products, wool) from sheep farming to increase their income and profitability.

Keywords: Data envelopment, Economic efficiency, Kars, Sheep farming.

INTRODUCTION

Sheep farming is one of the important animal production activities that meet many human needs, both directly (meat, milk, wool and offal) and indirectly (sausage casing, surgical thread, medicine and cosmetics) (Günlü and Mat, 2021). In addition, sheep farming is a livestock subsector that can utilize agricultural lands that are not suitable for plant production and low-yield pastures and creates employment in rural areas.

There are 1.3 billion sheep worldwide (FAO, 2024). Sheep farming is mainly concentrated between 35-55° north latitudes in Europe and Asia and 30-45° south latitudes in South America, Australia, and New Zealand. Türkiye is located between 36-42° north latitude, with wide pasture areas suitable for sheep breeding. Türkiye ranks 7th in the world with approximately 42 million sheep (FAO, 2024; TÜİK, 2024). Türkiye is a deep-rooted agricultural and animal husbandry country in which sheep have been bred for thousands of years. Sheep farming in Türkiye is not only an economic activity but also an important part of Turkish culture and lifestyle. Sheep farming, an indispensable element of nomadic life in the past, continues to be an important source of income for many people living in rural areas.

However, in recent years, difficulties in employing labor (shepherds, etc.), increasing input costs, inefficient/decreased pastures, animal diseases, problems in marketing animal products obtained from sheep (low demand or sales below cost) and migration from rural areas to urban areas have negatively affected the profitability and sustainability of sheep farming (Aksoy and Yavuz, 2012; Demir et al., 2015). Specifically in sheep farming, for successful policies aimed at solving existing problems and for economically effective enterprises, primarily, the structural characteristics of the sheep farming sector must be well known and the deficiencies must be identified. Data Envelopment Analysis, which was also used in the current study, is used to reveal the efficiency and profitability of sheep farming enterprises, especially in economic terms.

Data Envelopment Analysis (DEA) is a nonparametric analysis method used to measure the relative efficiency of decision-making units (DMUs) that produce one or more outputs using multiple inputs. In economic analyses, it is often preferred to evaluate the efficiency of various DMUs, such as firms in different sectors, public institutions or geographical

Citation: Küçükoflaz M, Aydin E, Zaman CI, Ayyildiz AKIN M, Sariözkan S, Aydin AK (2025). Evaluation of economic efficiency of sheep farming enterprises in kars province by data envelopment analysis. *Online J. Anim. Feed Res.*, 15(2): 89-97. DOI: https://dx.doi.org/10.51227/ojafr.2025.11

regions. There are different DEA models such as CCR (Charnes, Cooper, Rhodes), BCC (Banker, Charnes, Cooper) and SBM (Slacks-Based Measure). There are many software programs available for DEA analyses (Deat, DEA Solver, Frontier Analyst, etc.). One of the most important advantages of DEA is that it reduces the efficiency values of DMUs with multiple inputs and outputs to a single result. As an efficiency measurement technique, DEA is based on linear programming, based on the relationship of multiple inputs and outputs. Linear programming is a mathematical technique aimed at the most efficient use of limited resources within a specific purpose (Gonzalez et al., 2022). Mathematically, the efficiency measurement of DEA can be expressed as the division of the sum of weighted outputs of the DMU by the sum of weighted inputs (Stichhauerova and Pelloneova, 2019). Data envelopment analysis, which is used in many sectors, is used in the field of livestock to measure the technical and economic efficiency of enterprises and clinics (Demir et al., 2012; Sarıözkan et al., 2023; Aydın et al., 2024).

In this study, it was aimed to reveal the economic activities of sheep farming enterprises in Kars Province using DEA and to present suggestions for inefficient enterprises to become effective.

MATERIALS AND METHODS

In the present study, data from 99 sheep farming enterprises in Kars province were used. Data for one year (2024) for sheep farming enterprises were obtained from face-to-face surveys (general information about the farm and owner of the farm, information about the cost items of the farm, and information about the income items of the farm). The results of this study were examined in three parts.

1) Descriptive information about the sheep enterprises

The owners were asked survey questions that included general information about themselves and their enterprises. The answers to the questions as a result of the survey were presented as percentages.

2) Cost, income and profitability status of the enterprises

Survey questions were asked to obtain seven input and five output data of the sheep enterprises.

Economic analysis method for determining the total cost, income and profit situations (Demir et al. 2012; Sarıözkan et al. 2023);

Total cost (TL) = Feed (roughage, concentrated feed) cost+ labor cost (family labor, foreign labor) + veterinary-health cost + maintenance-repair (vehicle, etc.) cost + depreciation cost (tractor, tool-equipment) + general administrative expense cost (transportation + communication, etc.) + other cost (shipping, invoices, shepherd dog, etc.)

Total income (TL) = Milk sales income (yoghurt, cheese, clotted cream) + animal sales income (sheep/yearling, lamb) + inventory value increase (IVI) + fertilizer income + government support

Profitability = Total Income-Total cost

Cost and income items of the sheep enterprises are given in Table 1.

Table 1 Cost and income items

Costs Items		Income Items	
1.	Feed costs	1.	Milk sales
2.	Labor costs	2.	Animal sales
3.	Veterinary and health costs	3.	Inventory value increases (IVI)
4.	Maintenance and repair costs	4.	Fertilizer sales
5.	Depreciation costs	5.	Government support
6.	General administrative costs		
7.	Other costs		

3) Data Envelopment Analysis (DEA)

In the created DEA economic efficiency model, 7 input variables (feed expense, labor expense, veterinary-health expense, maintenance-repair expense, depreciation expense, general administrative expense and other expenses) belonging to the enterprises were taken into account.

The obtained data were analyzed using the input-oriented CCR technique. In DEA, it is assumed that each unit has "m" inputs, "s" outputs and "n" decision-making units on the problem to be analyzed. The ith input amount of the jth decision-making unit is Xij ≥ 0 and the Yij parameter shows the ith output amount used by the jth decision-making unit. The mathematical expression of the CCR technique of the input-oriented fractional DEA model, where Yij ≥ 0, is as follows. Enb h_k=(∑_(r=1)^s 〖u_rk y_rk 〗)/(∑_(i=1)^m 〖v_ik X_ik 〗)

=(∑_(r=1)^s 〖u_rk y_rj 〗)/(∑_(i=1)^m 〖v_ik X_ij 〗)≤1; j=1,2,...,n

u_rk≥ 0; r=1,2,...,s

v_ik≥0; i=1,2,...,m

The CCR data envelopment analysis model can be transformed into the following model.

Enb h_k=∑_(k=1)^s 〖u_rk y_rk 〗 k=1,2,...,n

∑_(i=1)^m 〖v_ik X_ik 〗 u_rk≥ 0; r=1,2,...,s v_ik≥0; i=1,2,...,m

∑_(r=1)^s 〖u_rk y_rj 〗- ∑_(i=1)^m 〖v_ik X_ij 〗 ≤0; j = 1,2,...,n

Enb: Maximization; urk": Weight assigned to the rth output by decision unit k; vik": Weight assigned to the ith input by decision unit k; Yrk": Output produced by decision unit k for the rth output; Xik": ith input used by decision unit k; Yrj": rth output produced by jth DMU; Xij": ith input used by jth DMU (Aydın et al., 2014).

The problem here has been processed n times to determine the efficiency of all DMU scores, and weighted inputs and outputs have been selected to optimize the efficiency score of each decision-making unit. The efficiency value of each DMU is in the range of [0, 1]. If the efficiency score of the DMU is 1, the relevant decision-making unit is considered effective, while if the efficiency score is less than 1, it is not considered effective (Aydın et al., 2014; Khezrimotlagh et al., 2021).

The analysis was applied to a total of 99 sheep enterprises. For inputs, the 1st enterprise was coded as "G1 {I}", 2nd enterprise was coded as "G2 {I}",... and 99th enterprise was "G99 {I}", and for outputs, the 1st enterprise was coded as "C1 {O}", 2nd enterprise was "C2 {O}",... and 99th enterprise was "C99 {O}". In this study, MS Excel and EMS 1.3.0 were used for DEA, and IBM SPSS 25.0 package program was used for the independent sample t-test.

RESULTS AND DISCUSSION

According to the findings of this study, the average age of the owners of the enterprises, all of whom were male, was 46. It was determined that 3% of the owners of the enterprises were illiterate; 76.8% were primary and secondary school graduates; 19.2% were high school graduates; and 1% were university graduates. It was observed that the average experience of owners was 9 years (39.4% had 1-5 years, 25.3% had 6-10 years, 16.2% had 11-15 years, and 19.2% had 16 years and above experience). All owners who participated in the survey had their own enterprises. The survey revealed that 67.7% of the enterprises were farming only Akkaraman, 3% were farming only Morkaraman, and 29.3% were farming both the breeds. The actual capacity of the enterprises was 365 sheep on average. The 25% of the owners of the enterprises stated that they preferred sheep farming because they “like sheep farming”, 37.8% because “there is pasture availability”, 12.2% because “the current sector is profitable”, 10.8% because “they want to earn additional income” and 14.2% because “there is government support”.

The proportional distribution of annual average cost and income items of Sheep farming enterprises in Kars is given in Table 2-3. The proportional distributions of the annual average cost and income items of sheep farming enterprises in Kars are presented in Tables 2-3. The proportional distribution of cost items of sheep farming enterprises, from largest to smallest, was as follows: 50.7% feed costs, 35.3% labor costs, 5.6% veterinary and health costs, 2.9% depreciation, 2.6% general administrative costs, 2.1% maintenance and repair costs, and 0.8% other costs (Table 2).

When the distribution of annual average income items of enterprises was examined, it was determined that inventory value increases had the highest share (58.6%), followed by animal sales income (36.4%), government support (3.4%), fertilizer income (1.1%), and milk sales income (0.5%) (Table 3). The efficiency scores of the enterprises according to the DEA results applied to the data of sheep farming enterprises are given in Table 4.

Table 2 - Distribution rates of cost items (%).

Cost Items	Share of total costs (%)
Feed costs	50.7
Labor costs	35.3
Veterinary and health costs	5.6
Maintenance and repair costs	2.9
Depreciation costs	2.6
General administrative costs	2.1
Other costs	0.8

Table 3 - Proportional distribution of income items (%).

Income Items	Share total income (%)
Inventory value increases (IVI)	58.6
Animal sales	36.4
Government support	3.4
Fertilizer sales	1.1
Milk sales	0.5

Table 4 - Economic efficiency scores of sheep farming enterprises

Decision unit (Sheep farming No)	Efficiency score	Benchmarks (Reference set)	Number of references shown by another decision unit	Efficiency status
Sheep farm 5	0.52	Sheep farm 3 (0.15) Sheep farm 4 (0.18) Sheep farm 6 (0.27) Sheep farm 34 (0.15) Sheep farm 36 (0.04) Sheep farm 62 (0.01) Sheep farm 83 (0.25)	0	Inefficient
Sheep farm 7	0.70	Sheep farm 4 (0.09) Sheep farm 6 (0.72) Sheep farm 34 (0.05) Sheep farm 36 (0.18) Sheep farm 59 (0.24) Sheep farm 83 (0.10)	0	Inefficient
Sheep farm 8	0.87	Sheep farm g 6 (1.19) Sheep farm 9 (0.04) Sheep farm 36 (0.38)	0	Inefficient
Sheep farm 12	0.80	Sheep farm 3 (0.06) Sheep farm 6 (0.94) Sheep farm 9 (0.30) Sheep farm 11 (0.09) Sheep farm 83 (0.02)	0	Inefficient
Sheep farm 14	0.72	Sheep farm 4 (0.21 Sheep farm 49 (0.39) Sheep farm 62 (0.35 Sheep farm 83 (0.01) Sheep farm 96 (0.28) 98 (0.04)	0	Inefficient
Sheep farm 15	0.94	Sheep farm 2 (0.20) Sheep farm 6 (1.40) Sheep farm 47 (0.36) Sheep farm 83 (0.38)	0	Inefficient
Sheep farm 16	0.71	Sheep farm (0.12) Sheep farm 6 (1.11) Sheep farm 19 (0.02 Sheep farm 38 (0.04) Sheep farm 39 (0.10)	0	Inefficient
Sheep farm 17	0.61	Sheep farm 3 (0.29) Sheep farm 62 (0.03) Sheep farm 74 (0.00) Sheep farm 83 (0.37)	0	Inefficient
Sheep farm 18	0.97	Sheep farm 3 (0.48) Sheep farm 13 (0.09) Sheep farm 49 (1.98) Sheep farm 90 (0.25)	0	Inefficient
Sheep farm 20	0.72	Sheep farm 39 (0.10) Sheep farm 74 (0.03) Sheep farm 83 (0.64 Sheep farm 90 (0.02) Sheep farm 96 (0.30)	0	Inefficient
Sheep farm 21	0.66	Sheep farm 6 (0.03) Sheep farm 11 (0.08) Sheep farm 36 (0.05 Sheep farm 47 (0.00) Sheep farm 49 (0.51) Sheep farm 83 (0.24)	0	Inefficient
Sheep farm 22	0.93	Sheep farm 6 (0.47) Sheep farm 13 (0.00) Sheep farm 31 (0.51) Sheep farm 39 (0.14)	0	Inefficient
Sheep farm 25	0.76	Sheep farm 39 (0.02) Sheep farm 49 (0.70) Sheep farm 74 (0.02) Sheep farm 83 (0.19) Sheep farm 96 (0.21)	0	Inefficient
Sheep farm 27	0.90	Sheep farm 39 (0.26) Sheep farm 83 (0.22) Sheep farm 96 (0.42) Sheep farm 98 (0.04)	0	Inefficient
Sheep farm 28	0.88	Sheep farm 34 (0.52) Sheep farm 36 (0.10) Sheep farm 39 (0.37) Sheep farm 49 (0.05) Sheep farm 59 (0.17)	0	Inefficient
Sheep farm 29	0.97	Sheep farm 4 (0.21) Sheep farm 39 (0.07) Sheep farm 47 (0.10) Sheep farm 65 (0.39) Sheep farm 83 (0.02) Sheep farm 96 (0.10)	0	Inefficient
Sheep farm 32	0.99	Sheep farm 36 (0.13) Sheep farm 39 (0.09) Sheep farm 45 (0.17) Sheep farm 59 (0.04) Sheep farm 68 (0.56)	0	Inefficient
Sheep farm 33	0.88	Sheep farm 4 (0.38) Sheep farm 34 (0.15 Sheep farm 38 (0.03 Sheep farm 39 (0.04) Sheep farm 47 (0.12) Sheep farm 59 (0.19)	0	Inefficient
Sheep farm 35	0.76	Sheep farm 39 (0.07) Sheep farm 74 (0.03) Sheep farm 83 (0.30) Sheep farm 96 (0.51) Sheep farm 98 (0.09)	0	Inefficient
Sheep farm 41	0.67	Sheep farm 1 (0.25 Sheep farm 3 (0.10) Sheep farm 6 (0.05) Sheep farm 36 (0.07) Sheep farm 62 (0.03) Sheep farm 83 (0.25)	0	Inefficient
Sheep farm 42	0.88	Sheep farm 6 (0.50) Sheep farm 36 (0.17) Sheep farm 39 (0.03 Sheep farm 59 (0.17 Sheep farm 81 (0.01)	0	Inefficient
Sheep farm 43	0.66	Sheep farm 4 (0.05) Sheep farm 6 (0.52) Sheep farm 47 (0.08) Sheep farm 60 (0.01) Sheep farm 83 (0.42)	0	Inefficient
Sheep farm 44	0.84	Sheep farm 36 (0.60) Sheep farm 48 (0.15 Sheep farm 83 (0.19)	0	Inefficient
Sheep farm 46	0.70	Sheep farm 3 (0.08) Sheep farm 9 (0.22) Sheep farm 13 (0.27) Sheep farm 36 (0.51)	0	Inefficient
Sheep farm 50	0.89	Sheep farm 60 (0.01) Sheep farm 62 (0.54) Sheep farm 73 (0.50)	0	Inefficient
Sheep farm 51	0.94	Sheep farm 1 (0.11) Sheep farm 2 (0.04) Sheep farm 3 (0.28) Sheep farm 4 (0.23) Sheep farm 11 (0.12) Sheep farm 83 (0.72)	0	Inefficient
Sheep farm 52	0.57	Sheep farm 3 (0.00) Sheep farm 4 (0.06) Sheep farm 6 (0.74) Sheep farm 38 (0.00) Sheep farm 39 (0.20) Sheep farm 45 (0.11) Sheep farm 47 (0.09)	0	Inefficient
Sheep farm 53	0.89	Sheep farm 3 (0.35) Sheep farm 6 (0.18) Sheep farm 62 (0.03) Sheep farm 83 (0.24)	0	Inefficient
Sheep farm 56	0.81	Sheep farm 49 (0.42) Sheep farm 74 (0.10) Sheep farm 83 (0.33) Sheep farm 96 (0.25)	0	Inefficient
Sheep farm 57	0.86	Sheep farm 47 (0.11) Sheep farm 49 (0.70) Sheep farm 83 (0.13) Sheep farm 96 (0.03)	0	Inefficient
Sheep farm 58	0.96	Sheep farm 6 (0.34) Sheep farm 34 (0.02) Sheep farm 38 (0.01) Sheep farm 39 (0.11) Sheep farm 47 (0.21) Sheep farm 49 (0.16)	0	Inefficient
Sheep farm 61	0.77	Sheep farm 39 (0.03) Sheep farm 40 (0.00) Sheep farm 49 (0.70) Sheep farm 74 (0.03) Sheep farm 76 (0.00) Sheep farm 83 (0.18) Sheep farm 96 (0.21)	0	Inefficient
Sheep farm 63	0.97	Sheep farm 39 (0.15) Sheep farm 74 (0.03) Sheep farm 83 (0.24) Sheep	0	Inefficient

		farm 96 (0.45) Sheep farm 98 (0.02)		
Sheep farm 64	0.92	Sheep farm 30 (0.24) Sheep farm 39 (0.21) Sheep farm 49 (0.46) Sheep farm 59 (0.08) Sheep farm 62 (0.04) Sheep farm 83 (0.01)	0	Inefficient
Sheep farm 66	0.95	Sheep farm 3 (0.05) Sheep farm 4 (0.27) Sheep farm 19 (0.00) Sheep farm 34 (0.20) Sheep farm 39 (0.20) Sheep farm 49 (0.44) Sheep farm 96 (0.13)	0	Inefficient
Sheep farm 67	0.90	Sheep farm 3 (0.09) Sheep farm 6 (0.28) Sheep farm 47 (0.01) Sheep farm 49 (0.22) Sheep farm 83 (0.28)	0	Inefficient
Sheep farm 69	0.83	Sheep farm 4 (0.06) Sheep farm 9 (0.06) Sheep farm 47 (0.23) Sheep farm 74 (0.08) Sheep farm 83 (0.33)	0	Inefficient
Sheep farm 70	0.96	Sheep farm 6 (0.31) Sheep farm 34 (0.44) Sheep farm 47 (0.08) Sheep farm 65 (0.14) Sheep farm 74 (0.05) Sheep farm 96 (0.10)	0	Inefficient
Sheep farm 71	0.81	Sheep farm 62 (0.03) Sheep farm 74 (0.09) Sheep farm 83 (0.30) Sheep farm 96 (0.51) Sheep farm 98 (0.05)	0	Inefficient
Sheep farm 72	0.89	Sheep farm 6 (0.04) Sheep farm 9 (0.01) Sheep farm 11 (0.68) Sheep farm 83 (0.05)	0	Inefficient
Sheep farm 75	0.99	Sheep farm 3 (0.53) Sheep farm 39 (0.44) Sheep farm 49 (0.25)	0	Inefficient
Sheep farm 77	0.48	Sheep farm 1 (0.11) Sheep farm 2 (0.02) Sheep farm 3 (0.10) Sheep farm 4 (0.18) Sheep farm 6 (0.12) Sheep farm 11 (0.01) Sheep farm 83 (0.29)	0	Inefficient
Sheep farm 78	0.97	Sheep farm 3 (0.01) Sheep farm 6 (0.43) Sheep farm 59 (0.35) Sheep farm 83 (0.06)	0	Inefficient
Sheep farm 79	0.57	Sheep farm 4 (0.14) Sheep farm 34 (0.04) Sheep farm 36 (0.16) Sheep farm 49 (0.00) Sheep farm 59 (0.08) Sheep farm 83 (0.41)	0	Inefficient
Sheep farm 80	0.73	Sheep farm 6 (0.28) Sheep farm 9 (0.04) Sheep farm 36 (0.28) Sheep farm 83 (0.40)	0	Inefficient
Sheep farm 82	0.72	Sheep farm 34 (0.15) Sheep farm 39 (0.27) Sheep farm 45 (0.22) Sheep farm 59 (0.63)	0	Inefficient
Sheep farm 84	0.76	Sheep farm 3 (0.07) Sheep farm 4 (0.04) Sheep farm 6 (0.19) Sheep farm 9 (0.06) Sheep farm 36 (0.01) Sheep farm 45 (0.27) Sheep farm 48 (0.07) Sheep farm 83 (0.26)	0	Inefficient
Sheep farm 85	0.98	Sheep farm 3 (0.02) Sheep farm 39 (0.04) Sheep farm 49 (0.84) Sheep farm 62 (0.01) Sheep farm 83 (0.03) Sheep farm 96 (0.02)	0	Inefficient
Sheep farm 86	0.79	Sheep farm 62 (0.29) Sheep farm 83 (0.29) Sheep farm 96 (0.34) Sheep farm 98 (0.18)	0	Inefficient
Sheep farm 87	0.95	Sheep farm 2 (0.11) Sheep farm 3 (0.18) Sheep farm 4 (0.26) Sheep farm 6 (0.35) Sheep farm 11 (0.32) Sheep farm 83 (0.50)	0	Inefficient
Sheep farm 88	0.64	Sheep farm 4 (0.14) Sheep farm 6 (0.97) Sheep farm 34 (0.00) Sheep farm 38 (0.04) Sheep farm 39 (0.12) Sheep farm 47 (0.03) Sheep farm 65 (0.00)	0	Inefficient
Sheep farm 89	0.64	Sheep farm 3 (0.19) Sheep farm 62 (0.08) Sheep farm 74 (0.06) Sheep farm 83 (0.35)	0	Inefficient
Sheep farm 91	0.84	Sheep farm 3 (0.39) Sheep farm 13 (0.33) Sheep farm 24 (0.14) Sheep farm 49 (0.21) Sheep farm 62 (0.03)	0	Inefficient
Sheep farm 92	0.95	Sheep farm 49 (0.36) Sheep farm 74 (0.11) Sheep farm 83 (0.47) Sheep farm 96 (0.20)	0	Inefficient
Sheep farm 93	0.71	Sheep farm 6 (0.09) Sheep farm 49 (0.40) Sheep farm 83 (0.49)	0	Inefficient
Sheep farm 94	0.74	Sheep farm 3 (0.04) Sheep farm 6 (0.26) Sheep farm 13 (0.02) Sheep farm 31 (0.67) Sheep farm 39 (0.08)	0	Inefficient
Sheep farm 97	0.91	Sheep farm 49 (0.34) Sheep farm 74 (0.04) Sheep farm 83 (0.53) Sheep farm 96 (0.24)	0	Inefficient
Sheep farm 99	0.91	Sheep farm 3 (0.05) Sheep farm 60 (0.18) Sheep farm 62 (0.21) Sheep farm 73 (0.27) Sheep farm 83 (0.01)	0	Inefficient

The efficiency scores of the enterprises, according to the DEA results applied to the data of sheep farming enterprises, are presented in Table 4. According to the DEA results for economic efficiency, 41 enterprises were found to be efficient (efficiency score = 1) and 58 enterprises were found to be inefficient (efficiency score <1). Sheep enterprise 1, was referenced a total of 3 times (by enterprises 41, 51, and 77); enterprises 3, a total of 21 times (by enterprises 5, 12, 17, 18, 41, 46, 51, 52, 53, 66, 67, 75, 77, 78, 84, 85, 87, 89, 91, 94, and 99); enterprise 4, a total of 16 times (by enterprises 5, 7, 14, 16, 29, 33, 43, 51, 52, 66, 69, 77, 79, 84, 87, and 88); enterprise 6, a total of 25 times (by enterprises 5, 7, 8, 12, 15, 16, 21, 22, 41, 42, 43, 52, 53, 58, 67, 70, 72, 77, 78, 80, 84, 87, 88, 93, and 94); enterprise 39, a total of 22 times (by enterprises 16, 20, 22, 25, 27, 28, 29, 32, 33, 35, 42, 52, 58, 61, 63, 64, 66, 75, 82, 85, 88, and 94); enterprise 49, a total of 19 times (by enterprises 14, 18, 21, 25, 28, 56, 57, 58, 61, 64, 66, 67, 75, 79, 85, 91, 92, 93 and 97); enterprise 62, a total of 13 times (by enterprises 5, 14, 17, 41 50, 53, 64, 71, 85, 86, 89, 91 and 99); enterprise 83, a total of 39 times (by enterprises 5, 7, 12, 14, 15, 17, 20, 21, 25, 27, 29, 35, 41, 43, 44, 51, 53, 56, 57, 61, 63, 64, 67, 69, 71, 72, 77, 78, 79, 80, 84, 85, 86, 87, 89, 92, 93, 97 and 99); enterprise 96, a total of 17 times (by enterprises 14, 20, 25, 27, 29, 35, 56, 57, 61, 63, 66, 70, 71, 85, 86, 92 and 97). The DEA input-oriented efficiency scores of sheep farming enterprises and residual values of variables (input elements that need to be reduced) are presented in Table 5.

Table 5 - Residual values of variables with Charnes Cooper Rhodes (CCR) input-side efficiency score of sheep farming enterprises (TL).

Sheep farming No	Efficiency score	Feed	Veterinary and health costs	Labor	Other	Maintenance and repair	Depreciation	General and administrative
Sheep farm 5	0.52	54,664.86	2,295.92	0	0	0	0	0
Sheep farm 7	0.70	1,581.05	37,643.95	0	0	0	0	0
Sheep farm 8	0.87	0	6,102.08	0	816.21	0	816.21	0
Sheep farm 12	0.80	1,524.67	0	8,683.37	0	0	0.0	0
Sheep farm 14	0.72	2,395.98	57,047.15	0	0	0.03	0.03	0
Sheep farm 15	0.94	2,577.01	1,988.13	71,353.78	0	5,881.55	5,881.55	0
Sheep farm 16	0.71	0	0	23,968.5	1,630.77	0.0	1,630.77	0
Sheep farm 17	0.61	279,649.7	0	82,452.11	0	17,306.71	17,306.71	0
Sheep farm 18	0.97	69,792.27	89,336.86	0	0	0	0	5,845.92
Sheep farm 20	0.72	0.02	6,675.77	0	0	0	0	0
Sheep farm 21	0.66	0	3,988.99	0	0	0	0	0
Sheep farm 22	0.93	74,907.35	0	199,210.4	2,369.11	0	2,369.11	0
Sheep farm 25	0.76	4,970.83	3,458.58	0	0	18,864.82	18,864.82	1,426.27
Sheep farm 27	0.90	185,964.0	14,823.47	0	0	16,890.67	16,890.67	0.0
Sheep farm 28	0.88	614.07	881.77	0	0	9,617.28	9,617.28	0.0
Sheep farm 29	0.97	0	0	116,046,0	0	0	0	0.0
Sheep farm 32	0.99	41,799.67	0	0	21.22	0.76	21.98	1,255.95
Sheep farm 33	0.88	776.81	18,495.58	0	0	0	0	0
Sheep farm 35	0.76	27,139.62	9,722.76	0	0	11,717.66	11,717.66	1,925.6
Sheep farm 41	0.67	12,811.87	72,350.3	0	0	0	10,811.87	0.0
Sheep farm 42	0.88	6,417.32	0	0	0	0	0.0	192.52
Sheep farm 43	0.66	1,683.2	33,757.45	0	0	4,423.12	4,423.12	0.0
Sheep farm 44	0.84	19,960.12	2,679.09	0	0	0.0	0.0	711.33
Sheep farm 46	0.70	1,762.75	25,624.66	0	3,020.99	6,910.47	9,931.45	0
Sheep farm 50	0.89	285,668.7	54,678.61	147,082.5	0	0	0	0
Sheep farm 51	0.94	445.96	10,618.17	0	0	0	0	0
Sheep farm 52	0.57	17,865.6	0	0	0	0	0	0
Sheep farm 53	0.89	407,122.6	24,345.54	0	0	30,570.06	30,570.06	0
Sheep farm 56	0.81	1,351.85	24,156.89	3,751.86	0	3,745.07	3,745.07	0
Sheep farm 57	0.86	1,887.04	5,741.02	54,863.97	0	0	0	0
Sheep farm 58	0.96	56.47	1,344.45	0	0	0	0	0
Sheep farm 61	0.77	1,126.66	8,680.62	0	0	12,701.15	12,701.15	0
Sheep farm 63	0.97	287,770.0	31,201.36	0	0	24,185.29	24,185.29	0
Sheep farm 64	0.92	236.36	21,399.65	0	0	23,509.92	23,509.92	2,316.47
Sheep farm 66	0.95	652.58	0	0	0	10,876.34	10,876.34	0.0
Sheep farm 67	0.90	0	4,646.2	75,661.98	0	0	0	2465
Sheep farm 69	0.83	1,723.96	16,154.48	0	0	17,424.54	17,424.54	0.0
Sheep farm 70	0.96	14,869.92	15,038.91	132,530.6	0	11,869.92	0	5,319.75
Sheep farm 71	0.81	3,110.58	20,414.81	0	0	16,005.73	16,005.73	1,911.08
Sheep farm 72	0.89	75,168.67	0	26,897.12	0	0	0	3,061.97
Sheep farm 75	0.99	41,664.99	0	207,492.7	633.08	0	0	0
Sheep farm 77	0.48	1,966.47	46,820.7	0	0	0	0	0
Sheep farm 78	0.97	91,704.97	2,684.57	0	0	230.94	230.94	2,877.76
Sheep farm 79	0.57	1,223.17	29,123.08	0	0	0	0	0
Sheep farm 80	0.73	2,261.32	0	0	0	0	0	67.84
Sheep farm 82	0.72	1,096.97	7,579.32	0	8,651.54	0	8,651.54	0
Sheep farm 84	0.76	11,458.4	0	0	0	0	0	0
Sheep farm 85	0.98	77,828.88	0	0	0	0	0	2,334.87
Sheep farm 86	0.79	426,808.5	66,926.16	0	0	11,668.68	11,668.68	0
Sheep farm 87	0.95	621.73	14,803.18	0.01	0	0	0	0
Sheep farm 88	0.64	12,653.3	0	0	0	0	0	0
Sheep farm 89	0.64	344,101.5	0	53,012.13	0	16,910.61	16,910.61	0
Sheep farm 91	0.84	280,702.6	0	0	0	9,740.96	9,740.96	0
Sheep farm 92	0.95	0	39,388.17	225,498.4	0	8,614.59	8,614.59	0
Sheep farm 93	0.71	2,254.31	1,096.5	72,024.61	0	791.9	791.9	0
Sheep farm 94	0.74	12,936.66	0	73,280.32	415.83	0	415.83	2,623.93
Sheep farm 97	0.91	82,928.75	13,725.94	0	0	26,353.74	26,353.74	4,645.58
Sheep farm 99	0.91	185,451.2	0	14,095.73	0	6,771.26	6,771.26	0

Table 6 - Average economic data for effective and ineffective sheep farming enterprises

Variable (average) \ Group	Effective	Ineffective
Actual capacity (head)	409	334
Total cost, TL ($)	1,271,524 (36,855.7)	1,370,421 (39,722.3)
Total income, TL ($)	2,826,651 (81,931.9)	2,171,374 (62,938.3)
Profit TL ($)	1,555,127 (45,076.1)	800,953 (23,216.0)

$1= 34.5 TL (28.11.2024)

The average actual capacity and economic data (income, costs, and profit) of the effective and ineffective sheep farming enterprises are presented in Table 6.

According to the study findings, the average actual capacity, average total income, and average net profit of effective enterprises were higher than those of ineffective enterprises, and their average total costs were lower. Concerning the profitability, it was determined that economically effective enterprises made an average of 754,174 TL ($21,860.1) more profit than enterprises that were ineffective (Table 6).

In Kars Province, located in the Eastern Anatolia Region of Turkey, animal husbandry is the most important source of income for the local people, as the climatic conditions are not suitable for agriculture and there are large pasture areas. For sustainable sheep and cattle farming, which is extremely important for the people of the region, breeders must have economically effective enterprises. In the current study, the economic effectivities of sheep enterprises in Kars Province were revealed through the DEA method, which is used to determine the effectivities of enterprises in many areas. Although there are studies supporting the findings of the current study in terms of the gender, age, and education status of enterprise owners (Dossa et al., 2008; Demir et al., 2015; Tamer and Sarıözkan, 2017), this study have shown that the education level of those engaged in sheep farming, which is a sub-sector of livestock, is lower and the average age is higher compared to other livestock sub-sectors (broiler/egg chicken farming, cattle farming; Sarıözkan and Sakarya, 2006; Yalçın, et al., 2010). The average experience of the owners of the enterprises participating in the survey was determined as 9 years, which is consistent with the study conducted (Demir et al., 2015) in Ardahan Province. The fact that 39.4% of the participants had 1-5 years of experience shows that the support and incentives given by the government in recent years, as well as the presence of pastures in the region, have caused farm owners to turn to sheep farming, which they like. It has been thought that owners prefer Akkaraman or Morkaraman breeds due to factors such as the good adaptation of these breeds to the region, their resistance to diseases and the lower losses of sheep/yearlings and maternal animals, especially lambs than other breeds. When the proportional distribution of input items of the enterprises was examined, it was determined that the largest proportion belonged to feed cost (50.7%). This was followed by labor (35.3%), veterinary-health (5.6%), maintenance-repair (2.9%), depreciation (2.6%), general administrative (2.1%), and other costs (0.8%). Data from previous studies (Demir et al., 2015; Tamer and Sarıözkan, 2017) conducted in different regions of Türkiye are consistent with the findings of the current study. In the study conducted by Tamer and Sarıözkan (2017), the proportional distribution of costs is as follows, respectively: feed (59.5%), labor (23.2%), veterinary-health (6%), depreciation (3.3%), maintenance-repair (2.7%), general administrative (2.7%) and other costs (2.1%). In the study conducted by Demir et al. (2015) feed (48.9%) and labor (16.9%) costs had the largest share in costs, as in the current study. In the proportional distribution of the income items of enterprises, the highest share belongs to inventory value increase while the lowest share belongs to milk sales income. The largest share in income belongs to IVI was similar to the study of (Tamer and Sarıözkan, 2017). In the current study, the reasons for the low milk sales income were listed as the low amount of milk obtained from sheep, milk being given to lambs, insufficient labor force, and insufficient demand for milk and dairy products obtained from these animals (Morris, 2017).

CONCLUSION

In this study, the efficiency scores of sheep farming enterprises in Kars Province were determined for the first time using Data Envelopment Analysis, and it was determined that 41 out of 99 enterprises were effective and 58 were ineffective. It has been determined that ineffective enterprises must reduce the costs of some input items specific to their own enterprises. It was thought that ineffective enterprises need to make progress in obtaining, processing, branding, and marketing high value-added products (milk/dairy products and meat/meat products) from sheep farming, in addition to reducing their costs in order to become effective. In addition, the productivity and quality of the pasture assets in Kars province should be increased by improving them and exchanging grazing them. Effective organizational structures (cooperatives and producer unions) regarding sheep farming need to be established in the region. Thus, it is possible for enterprises to increase their incomes and make farming more profitable. This DEA study can also provide guidance for enterprises in this province to achieve economically effective and profitable production.

DECLARATIONS

Corresponding author
Correspondence and requests for materials should be addressed to Mehmet KÜÇÜKOFLAZ; E-mail: mehmetoflaz38@gmail.com; ORCID: https://orcid.org/0000-0003-3256-4735

Data availability
The data and materials of this study are available from the corresponding author.

Authors' contribution
M.Küçükoflaz, and E. Aydın: designed the research, supervision, writing, and editing.
C.İ. Zaman, and A.K. Aydın: investigation, collecting the data.
S. Sarıözkan: writing, and review.
M. Ayyıldız Akın: analysis.

Consent to publish
All authors have read and approved the final version of the manuscript and give their consent for publication.

Funding sources
None.

Ethical considerations
No invasive intervention was performed on the animals. This study does not present any ethical concerns.

Competing interests
The authors declare no competing interests in this research and publication.

REFERENCES

Aksoy A and Yavuz F (2012). Çiftçilerin küçükbaş hayvan yetiştiriciliğini bırakma nedenlerinin analizi: Doğu Anadolu Bölgesi örneği [Analysis on the reasons for quitting sheep and goat rearing of farmers: a case of east Anatolia region]. Anadolu Tarım Bilimleri Dergisi, 27(2): 76-79. https://doi.org/10.7161/anajas.2012.272.76

Aydin E, Yeşilyurt C, and 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. https://vetdergikafkas.org/uploads/pdf/pdf_KVFD_1657.pdf

Aydın E, Zaman Cİ, Küçükoflaz M and Akın MA (2024). Evaluation of economic efficiencies of veterinary practices in Kars province with data envelopment analysis. Veterinary Sciences and Practices, 19(2): 112-123. https://doi.org/10.17094/vetsci.1455906

Demir P, Derbentli Ö, Sakarya E (2012). Kars ilinde bulunan mandıraların etkinliğinin veri zarflama analizi ile ölçülmesi [Measurement the efficiency of dairies in the kars province with data envelopment analysis]. Kafkas Üniversitesi Veteriner Fakültesi Dergisi, 18(2): 169-176. https://vetdergikafkas.org/uploads/pdf/pdf_KVFD_1075.pdf

Demir PA., Işık SA, Aydın E, Yazıcı K and Ayvazoğlu C (2015). Socio-economic Importance of Sheep Breeding Farms in Ardahan Province. Van Veterinary Journal. 26(3): 141- 146. https://dergipark.org.tr/tr/download/article-file/217589

Dossa LH, Rischkowsky B, Birner R and Wollny C (2008). Socio-economic determinants of keeping goats and sheep by rural people in southern Benin. Agriculture and human values, 25: 581-592. https://doi.org/10.1007/s10460-008-9138-9

Gonzalez M, López-Espín JJ, Aparicio J, and Talbi EG (2022). A hyper-matheuristic approach for solving mixed integer linear optimization models in the context of data envelopment analysis. PeerJ Computer Science, 8: e828. https://doi.org/10.7717/peerj-cs.828

Günlü A and Mat B (2021). The place and importance of sheep and goat breeding in the Turkish economy. Sheep and goat health and breeding in preventing lamb and kid losses. (1. Baskı, s. 3-14). Ankara, Akademisyen Yayınevi. https://doi.org/10.37609/akya.902

Khezrimotlagh D, Cook WD and Zhu J (2021). Number of performance measures versus number of decision-making units in DEA. Annals of Operations Research, 303: 529-562. https://doi.org/10.1007/s10479-019-03411-y

Morris ST (2017). Overview of sheep production systems. Advances in Sheep Welfare, Woodhead Publishing, Elsevier. Pp. 19-35. https://doi.org/10.1016/B978-0-08-100718-1.00002-9

Sarıözkan S and Sakarya E (2006). Afyon ili yumurta tavukçuluğu işletmelerinde karlılık ve verimlilik analizleri [The profitability and productivity analyses of layer hen enterprises in Afyon Province]. Lalahan Hayvancılık Araşaştırma Enstitüsü Dergisi 46(1): 29-44. https://dergipark.org.tr/tr/download/article-file/544283

Sarıözkan S, Akçay A, Küçükoflaz M, Güngör G and Gürbulak EÇ (2023). Kayseri ili yumurta tavukçuluğu işletmelerinde verimlilik ve karlilik analizleri [Productivity and profitability analysis of laying hen farms in Kayseri Province]. Erciyes Üniversitesi Veteriner Fakültesi Dergisi, 20(1): 47-56. https://doi.org/10.32707/ercivet.1259622

Stichhauerova, E. and Pelloneova, N (2019). An efficiency assessment of selected German airports using the DEA model. Journal of Competitiveness. 11(1): 135-151. https://doi.org/10.7441/joc.2019.01.09

Tamer B and Sarıözkan S (2017). Yozgat merkez ilçede koyunculuk yapan işletmelerin sosyo-ekonomik yapısı ve üretim maliyetleri [Socio-economic structure and production costs of sheep farms in central district of Yozgat province]. Erciyes Üniversitesi Veteriner Fakültesi Dergisi 14(1): 39-47. https://dergipark.org.tr/en/download/article-file/288323

The Food and Agriculture Organization (FAO) (2024). Access address https://www.fao.org/sustainable-development-goals-helpdesk/overview/sdg-progress-and-alignment/2030-agenda-follow-up-and-review/expert-group-meeting-on-sdg-2/ - Access Date: 22.09.2024.

Turkish Statistical Institute (TÜİK) (2024). Access address: https://biruni.tuik.gov.tr/ilgosterge/?locale=tr Access Date: 19.10.2024

Yalçın C, Yıldız AŞ, Sarıözkan S and Günlü A (2010). Producer profiles, production characteristics and mastitis control applications at dairy herds in Konya, Burdur and Kırklareli provinces, Turkey. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 57: 43-48. http://vetjournal.ankara.edu.tr/en/download/article-file/698718