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RESEARCH ARTICLE

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The impacts of agricultural support on enhancing the efficiency, competitiveness and sustainability of sheep breeding: The case of Niğde and Aksaray provinces, Turkey

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Abstract

Aim of study: The sheep breeding sector in Turkey has lost its potential to become a highly competitive and efficient sector despite a number of policies being implemented over the years. Therefore, the objective of the study was to empirically evaluate the competitiveness of sheep breeding and the determinants of the technical efficiency of the sector as well as the current impacts of agricultural policies on the performance of the sector.

Area of study: Niğde and Aksaray provinces of TR71 region in Turkey.

Material and methods: The required primary data were obtained through a face-to-face survey from 110 sheep breeders. Two methodological approaches, namely Stochastic Frontier Analysis and Policy Analysis Matrix, were used.

Main results: The support policies caused an inefficiency in allocation of already scarce resources in sheep breeding, but not ensure to increase the competitiveness at both national and international levels. Sheep farms could increase their income by up to 50% without changing the level of input by taking into account the factors that caused inefficiency in sheep breeding. The major determinants that decreased efficiency were current subsidies for sheep breeding, herd size and the excessive utilization of family labour, while the factors that increased the efficiency were sheep race, access to extension services, grazing period and location. Besides, Domestic Resource Cost (DRC) value in the efficient farms decreased to 0.88, implying that they had a comparative advantage.

Research highlights: Implementation of structural support policies with long term would enhance efficiency of sheep farms and ensure the sustainability and competitiveness of the sector.

Additional key words: policy impact; stochastic frontier analysis; policy analysis matrix

Abbreviations used: DRC (Domestic Resource Cost); EPC (Effective Protection Coefficient); FOB (Free on Board); LCF (Labour Conversion Factor); NPCI (Nominal Protection Coefficient for Inputs); NPCO (Nominal Protection Coefficient for Outputs); PAM (Policy Analysis Matrix); PCR (Private Cost Ratio); SCB (Social Cost Benefit); SFA (Stochastic Frontier Analysis); TE (Technical Efficiency); TL (Turkish Lira)

Authors' contributions: This manuscript has one author who conceived and designed the study, performed the data search, analysed the data and wrote the manuscript.

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Introduction

The dynamic changes and developments in the world have led to the escalation of the debate of how to more efficiently allocate scarce resources to ensure food security and social welfare. This debate has caused significant advancements in the agricultural policies of developed, developing and less developed countries. The implementation of agricultural policies targeting more efficient resource use can enable a faster and more stable economic development in the sector. This is because creating efficiency in these sectors is more important than possessing them. The food crises encountered around the world clearly reveal the importance of efficient resource use.

Thus, the most important objective of agricultural supports in many countries is to improve the productivity, efficiency and competitiveness of individual farms as well as the agricultural sector (OECD, 2011).

On the other hand, the fiscal burden of these policies on the economy and their market distortion effects are a subject of another worldwide debate. The concern for the economic and social cost of agricultural supports is particularly more acute in developing countries. For this reason, understanding the impacts of support policies on the competitiveness and effectiveness of a commodity system is crucial in formulating effective support policies to ensure food security and economic development.

Competitiveness is one of the main factors that determine production efficiency. This is because competitiveness includes not only the issues of possessing resources and the quality of these resources, but also the use and organisation of these resources. In other words, the more efficient the agricultural sector the higher the productivity and, thus, the stronger the competitiveness. Moreover, understanding the relationship between efficiency and competitiveness could enable the comprehension of how this information can contribute to sustainability.

As a result of various complex issues, the sheep breeding sector in Turkey has lost its potential to become a highly competitive and efficient sector despite a number of policies being implemented over the years. However, this sector had a comparative advantage over the other livestock sectors, as in the past, Turkey was one of the major exporter countries in terms of live sheep and meat. In addition, when the necessity for adequate and balanced nutrition is considered, it can be said that red meat is a strategic food for countries. However, the per capita consumption level of red meat based on bovine and small ruminant in Turkey (at 17.1 kg/year) is lower than the averages of developed countries (26.0 kg/year in France, 24.9 kg/year in Greece, and 22.1 kg/year in the UK) (FAO, 2019). Although Turkey is one of the major countries in terms of the number of sheep, it currently has a deficit of around 1.5 million tonnes of red meat. The inability of Turkey to achieve self-sufficiency in sheep meat is based on low productivity, inefficiency in production and inconsistencies in agricultural policies. Thus, it is necessary to investigate the factors that foster the sustainability of the sector in order to implement effective policies. However, this requires empirical information on efficiency and the level of competitiveness in sheep breeding and the effects of policy intervention on the sector.

A number of studies in the literature have investigated both the efficiency and comparative advantage of various sub-sectors of agriculture. Nurwahidah *et al.* (2015) analyzed the efficiency level and competitiveness level of farming on dry land and wetland in Sumbawa by using Policy Analysis Matrix (PAM) and Stochastic Frontier Analysis (SFA) methods. Additionally, Latruffe (2010) reviewed the literature on competitiveness, productivity and efficiency used in agriculture and agri-food sectors by clarifying the concept and terminology. Fatah (2017) examined the competitiveness and efficiency of rice production and the changes in farm level efficiency in Malaysia over time. Usman (2015) analysed the efficiency and competitiveness of rice production systems in three states of North Nigeria. Akter *et al.* (2003) investigated the competitiveness and efficiency of the production of local, crossbred and exotic breeds of poultry and pig in North and South Vietnam. Antriyandarti (2015) examined the impacts of efficiency improvement on the global competitiveness of the Indonesian rice sector. Bozoglu *et al.* (2017) investigated the economic sustainability of family dairy farming activity within the scope of technical efficiency (TE) in the Bafra district of Turkey. Eroglu & Bozoglu (2019) examined the profitability of cattle breeding farms depending on livestock supports and external input rates in the province of Samsun, Turkey. Eroglu *et al.* (2019) analysed the impacts of livestock supports on production and income of beef cattle farms in Samsun of Turkey. However, the issue of the associated impacts of agricultural supports on the competitiveness and efficiency of farms, and their interactions have not been empirically examined in the literature. For this reason, the present study aimed to address this critical research gap in the sector by uncovering this issue with evidence from the sheep breeding sector in Turkey.

Within this context, the overall objective of this study was to empirically analyse the current impact of agricultural policies on the performance of the sheep breeding sector in the provinces of Niğde and Aksaray in Turkey, in terms of competitiveness and efficiency. This study specifically aimed to make two important contributions: 1) determine the factors influencing sheep breeding production, ascertain the factors affecting the technical inefficiency of sheep breeders, and examine the competitiveness in sheep breeding among farmers in the study area and 2) understand the impact of agricultural supports on the allocation of production resources and the factors behind competitiveness.

Material and methods

Overview of the Turkish sheep sector and support policies

The production of animals is important in terms of providing the nutritional requirements of a population. The amount of livestock production should be increased in accordance with the increase in population. Despite slowing down, the population growth rate in Turkey continues. However, the production of red meat in particular has not increased in parallel with the increase in population.

When viewed from this perspective, as with the production of all animals, the production of sheep, which is important in terms of meat and milk production, must be increased.

When the number of animals is considered, it can be said that Turkey is significantly engaged in animal husbandry. According to the FAO (2019), while Turkey is ranked eighth in the world in terms of the number of sheep, it is ranked second after the United Kingdom when compared with EU member countries. Even though Turkey has a huge potential in terms of sheep breeding, over time it has partially lost this potential. Despite the fact that Turkey's ecological conditions are suitable for small ruminant rearing, the current situation of the sector is still far from meeting expectations. The sheep population in Turkey declined by 7.8% in the last two decades reaching 37.3 million heads, 91.7% of which consists of a domestic race. In the same period, the number of slaughtered sheep decreased by 36.2%, while sheep meat production decreased by 15% (Fig. 1a). However, the share of the Merino race increased fourfold in the last two decades, which caused an increase in wool production by 16.7%. In addition, sheep milk production increased from 1.1 million tons to 1.5 million tons in the same period. The average meat yield was 21.6 kg per slaughtered sheep in 2019. Considering the foreign trade of the sheep sector in Turkey, no live sheep exportation was carried out. On the other hand, the live sheep import value of Turkey was 37.3 million dollars in 2017. Live sheep import has changed in accordance with the domestic demand over the years (Fig. 1b). Sheep meat trade is also a negligible level. According to TURKSTAT (2020) data, in the last decade, the increase in the real consumer prices for sheep meat (56%) was higher than the increase in real producer prices (24%).

In the last century, the Turkish government has implemented a number of policies aimed at improving animal production. However, the outcomes of these policies have been dissatisfactory. While the support for plant production is substantial within the agricultural policies in Turkey, the support for animal production has remained at a more limited level. The limited livestock support was concentrated primarily on increasing poultry and then dairy cattle farming, and neglected ovine breeding. During this period, support in other areas such as meat incentive premium, medicine and feed premium support regarding sheep and goat farming were provided for a very short time. As a result, significant problems have emerged in the livestock sector, particularly in the small ruminant sector. These policies implemented during this period

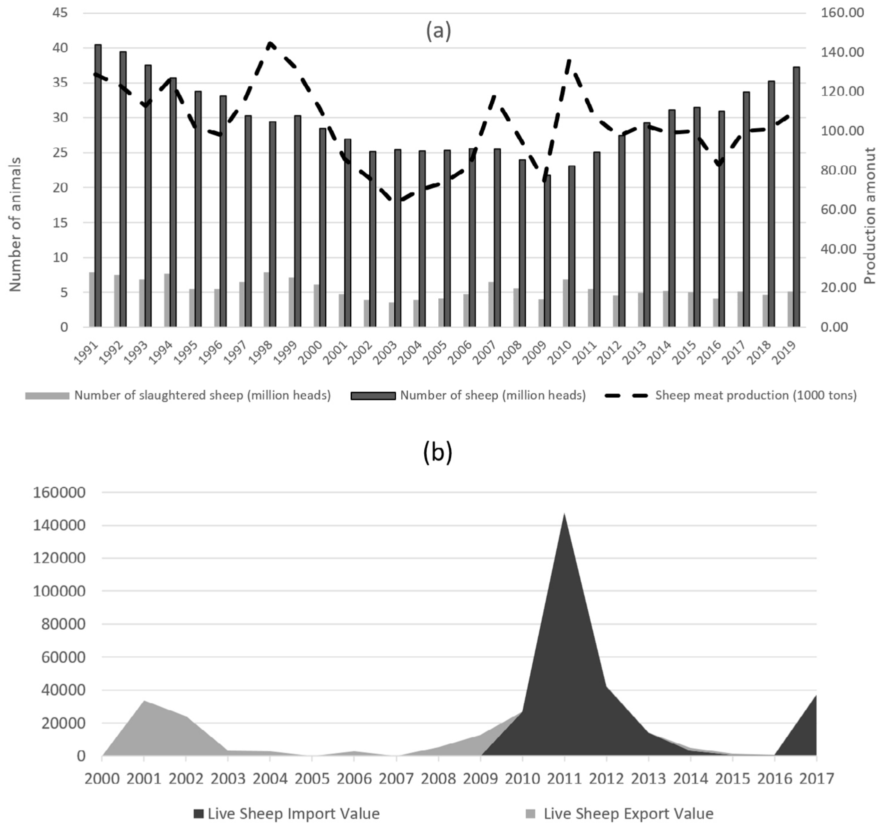

Figure 1. Developments in numbers of sheep and sheep meat production (a), live sheep trade value (million $) (b) in Turkey. *Source*: TURKSTAT (2020).

have adversely affected both the quality and quantity of small ruminant production. This has also caused instability in product prices and the incomes of producers. Consequently, sheep breeding has lost its appeal in Turkey and as of the mid-1980s, sheep stocks have reduced by 36%. Overall, this has adversely affected the competitiveness of the sector.

In the year 2000, the Turkish government started a new agricultural support system that was based on both internal and external factors in Turkey and changed the aims and instruments of agricultural support policies. Since then, several new regulations related to livestock support have been issued and the share of livestock supports in the total has increased from 0.5% to 30% (Anonymous, 2018). In the context of these improvements, sheep breeding farmers were provided 25 Turkish Lira (TL) per breeding female sheep in 2018. Additionally, vaccination subsidy for brucellosis and foot and mouth disease and tagging subsidy for small ruminants were provided to farmers separately as 1 TL per head. In the same year, shepherd support of 5000 TL was provided to farms that had a flock of at l200 or more sheep. The condition for the number of sheep was reduced to 100 in 2019. In addition, forage crop support based on the area was also provided to sheep breeding farmers. Despite these supports, the small ruminant sector in Turkey has not yet developed at the targeted level. The structure of sheep breeding in Turkey consists of low-yield native breeds that depend mainly on extensive grazing. Various problems are encountered in this sector such as the lack of input supply including feed and shepherds, the lack of product marketing and assessment opportunities and small- scale subsistence farming.

Data and modelling assumptions

The required primary data were obtained through an inclusive questionnaire applied to 110 farmers from the provinces of Niğde and Aksaray in Turkey in 2018. According to TURKSTAT (2019) data, there were approximately1.1 million sheep in the TR71 region. According to the Classification of Statistical Regions (SRE) at level 2, the TR71 region is comprised of the provinces of Kırıkkale, Aksaray, Niğde, Nevşehir and, Kırşehir. The provinces of Niğde and Aksaray constituted 70% of the total sheep amount in the region and 3.2% of the country. These two provinces were selected as the study area as sheep breeding is intensively carried out in both provinces. The Stratified Random Sampling method of Yamane (1967) was used to determine the sample size.

All variables of the model were calculated as an Animal Unit Equivalent (AUE) in order to adjust the different kinds and classes of livestock in a common form. The AUE coefficients used in the study were established according to the Pasture Regulation no 1998/23419 (Anonymous, 1998). The inputs in the TE analysis consisted of five components: total feed use (kg/AU), vaccination and veterinary expenses (TL/AU), total labour force use (man hours/AU), animal purchasing (TL/AU) and other variable costs (TL/AU).

The live carcass weight of sheep was selected as the output variable. All of the feeds used were converted to dry matter feed equivalent. The labour variable was comprised of both the hired and family labour used in sheep rearing throughout the year and was expressed as man-hours per AU. The animal purchasing costs covered the replacement of the herd. The other variable costs covered the relevant running costs such as electricity, water, disinfection, transportation, maintenance, equipment repairs, and pasture rent. The factors influencing inefficient sheep breeding were the region of the production unit, grazing duration, farmer experience, sheep race, subsidies, herd size, level of family labour used and access to extension services. Grazing duration was expressed as the days spent on the pasture during one year. Farmer experience was calculated as number of years. For each farm, the share of sheep breeding subsidies received in total gross income was taken as the subsidy rate. The inefficiency model consisted of four dummy variables related to sheep race, region and access to extension services. In the dummy variable related to sheep race, farmers were given a value of 1 if they reared Akkaraman race sheep and 0 if they reared other races. The dummy variable related to region was also included to reflect the regional variations between the provinces. In the study area, 45% of the sample farms were located in Aksaray, while the remaining 55% were located in Niğde.

The most difficult task when creating a PAM table, is estimating the social prices for inputs and outputs. Many factors such as subsidies, import tariffs, indirect taxes, overvalued exchange rates, overstated labour costs, other forms of administrative interventions and monopoly prices affect the domestic market prices of many products and services (JICA, 2015). In order to calculate the social prices in the PAM analysis, secondary data such as production subsidies, exchange rates, world prices, and import or export tariffs were also used. For this purpose, the inputs were disaggregated into tradable and non-tradable components, which is also a challenging task. Depending on whether the commodity was an exported or imported substitute, the CIF (cost insurance and freight) and FOB (free on board) prices were taken from TURKSTAT (2018) to calculate the social (reference) prices for tradable feeds and live animals. These prices were converted into local currencies by reel exchange rates. The social farm gate prices for both imported inputs and outputs were derived from the CIF price in domestic currency by adding on storage and transportation costs. To calculate the social farm gate prices for the exports, the storage and transportation costs were subtracted from the FOB prices calculated in domestic currency (Gürer *et al.*, 2017).

As the border prices of commodities such as agricultural labour, interest on working capital and other running costs were not available; these variables were considered as non-tradable goods and services.

Several methods were used to calculate the social values of these variables. To calculate the social value of the working capital, the reel interest rate was calculated in accordance with the methods of Mane-Kapaj *et al.* (2010) and Gürer *et al.* (2017). To convert the labour wage into an economic one, the Labour Conversion Factor (LCF), also known as the Shadow Wage Rate (SWR) was determined. The LCF is specified as the shadow wage (price) ratio (SPi) to a domestic market wage (price) (MWi) and calculated according to Eq. 1 (Jayanthakumaran, 2003).

$$LCFi=SWi/MWi \quad (1)$$

In this study, the shadow wage was considered as a marginal productivity of labour and estimated as a ratio of the value of total agricultural output at market prices to the total agricultural labour force at a national level (JICA, 2015). The literature review showed that many studies had used the conversion factor based on domestic price to estimate the reference prices of labour (Chen, 1993; Gürer *et al.*, 2017). Hence, the conversation factors of labour for the farms in the provinces of Niğde and Aksaray and the overall farms were calculated as 1.16, 1.60 and 1.41, respectively.

In addition, to reflect the effect of the distortions of agricultural policies, all input subsidies including vaccination support per animal, shepherd employment support and forage crops subsidy were subtracted from the cost calculated at market prices. Similarly, the payment of animal breeding per head was added to the annual gross income of sheep breeding calculated by adding the incomes acquired from animal, milk, manure and wool sales and stock residual value at market prices.

Stochastic frontier analysis

In this study, the SFA was used to estimate TE and the determinants of the inefficiency in sheep production depending on stochastic and unpredictable natural/environmental conditions. As the SFA method takes into account the random noise as part of the deviation from the production frontier, it was determined as the most appropriate method for this study. Frontier models have been commonly used by researchers to examine the TE of farms or farm activities (Battese, 1992; Bravo-Ureta *et al.*, 2007; Latruffe *et al.*, 2016).

In this study, the stochastic frontier function was represented by a log linear Cobb-Douglas production function, which was derived for the sheep-rearing farm to determine a possible increase in output without changing the uses of the inputs. By following the model of Battese & Coelli (1995), the production function and exogenous effects affecting the inefficiency were simultaneously estimated. Technical efficiency was estimated relatively according to the best performing farms in the sample. The equation of the SFA model is specified as follows:

$$Yi = \alpha + x_i \beta + v_i - u_i \quad (2)$$

The SFA explains that the output quantity of i^{th} farm determines both the efficiency of a subject and the noise effect (v_i). The noise effect, which represents the effect of random external factors, can be positive or negative. In addition, ui is a non-negative random variable related to inefficiency. Hence, the SFA model consists of a deterministic frontier, a noise effect and inefficiency.

To estimate all parameters of the maximum likelihood function, FRONTIER 4.1 software was used. The software estimates the $\gamma = \sigma^2 / \sigma s^2$ parameter, which takes a value between 0 and 1. The zero value of γ shows that all the deviations of the frontier could be explained completely by noise, while a value of 1 indicates that the deviations could be explained by technical inefficiency.

The TE of i^{th} farm is provided by the ratio of the observed output of the i^{th} farm relative to the potential output estimated by Equation 2. Thereby, technical efficiency (TE_i) is found using Equation 3:

$$TE_i = \exp(-u_i) \quad (3)$$

The TE coefficient acquires a value between 0 and 1, indicating farm efficiency between 0% and 100%.

Determining the presence of systematic inefficiency is important in the SFA. For this purpose, the inefficiency factors (TE effects) model, which includes external factors, was applied to the model in a single stage. The TE effect model (Equation 4) was obtained by including a linear function of the external factors of “u” in Equation 2 into the model. In Equation 4, ‘z’ is the explanatory external factors vector and ‘δ’ is the variable coefficient in the vector (Battese & Coelli, 1995).

$$Yi = \beta^* x_i + v_i - (\delta_i^* z_i) \quad (4)$$

Hypothesis tests for SFA

Four main hypotheses were tested in the study by using the generalized likelihood ratio (LLR) tests. The results of these hypothesis tests are presented in Table 1. The first was related to the functional form. The null hypothesis was accepted concluding that the Cobb-Douglas production function was a more adequate representation model

Table 1. Hypothesis tests for SFA

Test No.	Null hypothesis	Log likelihood value	t-statistics	$\chi^2_{0.99}$ value	Decision
1	H0:Cobb-Douglass=Translog	51.390	12.51	13.28	H_0 Accepted
		57.645			
2	H0: γ= δ0=…= δ9=0	12.641	77.50	21.67	H_0 Rejected
3	H0: γ=0	12.547	77.69	15.09	H_0 Rejected
4	H0: δ1=…= δ9=0	20.843	61.09	20.09	H_0 Rejected

in the stochastic frontier. The second hypothesis was conducted to test the effects of technical inefficiency. This was rejected, as the estimated generalized LLR test statistic of 77.50 was higher than the critical value range of 21.67 at a 1% significant level. The third hypothesis was that the model was an average response model, which implies that all the inefficiencies were due to factors outside the control of the farmers. This was rejected as the estimated generalized LLR test statistic was significantly different from zero at 1%. This implies that the ordinary average response function is not a suitable specification for sheep breeding in the area. Thus, non-controlled factors by the farmers were also responsible for the inefficiencies. The fourth test was conducted with the null hypothesis that eight specific explanatory variables did not have an effect upon the technical inefficiency. This hypothesis was also rejected indicating that the joint effect of these eight factors on the levels of technical inefficiency was significant, even though the individual effects of some of the variables were not statistically significant.

Policy analysis matrix

This study used PAM to investigate the competitiveness of sheep breeding. PAM, which was developed by Monke & Pearson (1989) and developed by Masters & Winter-Nelson (1995), measures the efficiency of input use in production, comparative advantages between commodities and the level of government interventions. PAM is a quantitative framework based on benefit-cost analysis and is used to evaluate the influence of policies on commodities. Costs and revenues are calculated for both market prices, the current observed prices paid or received by farmers and reference prices, the effect of distorting government policies such as subsidies and taxes on market prices (Table 2).

According to Table 2, a PAM table has two accounting identities. The first one comprises the profitability by calculating the difference between revenue and cost, while the second one measures the effects of distorting policies and market failures by calculating the difference between the observed market prices and prices without market distortions (Monke & Pearson, 1989). Hence, a PAM can account for the existing economic efficiencies of a commodity production system, the distortion degree on input and output markets, and the extent of resource transfers within an economy. Private profit (D) is the difference between revenues (A) and costs (B+C) in observed prices. Social profit (H), like private analogue, is the difference between revenues (E) and costs (F+G) in reference prices. Output transfers (I) and input transfers (J) arise from two kinds of policies that cause divergences between observed and world product prices: commodity-specific policies and exchange-rate policy. Factor transfer (K) causes private factor costs (C) to differ from social factor costs (G) and can be either positive (causing an implicit tax or transfer of resources away from the system) or negative (causing

Table 2. Framework of policy analysis matrix (PAM)

	Revenue	Costs		Profit
		Tradable inputs	Domestic factor	
Private prices	A	B	C	D
Social prices	E	F	G	H
Policy transfer	I	J	K	L
Private profit (D) = A-(B+C)		Input transfer (J) = B-F	Factor transfer (K) = C-G	
Social profit (H) = E-(F+G)		Output transfer (I) = A-E	Net policy transfer L= D-H or I-J-K	
NPCO = A/E		NPCI = B/F	EPC = (A-B)/(E-F)	
DRC = G/(E-F)		SCB = (F+G)/E	PCR = C/(A-B)	

DRC: domestic resource cost. EPC: effective protection coefficient. NPCI: nominal protection coefficient for inputs. NPCO: nominal protection coefficient for outputs. PCR: private cost ratio. SCB: social cost benefit. *Source*: Monke & Pearson (1989).

an implicit subsidy or transfer of resources in favour of the agricultural system). The net transfer caused by policy and market failures (L in the matrix) is the sum of the separate effects from the product and factor markets, L = (I - J - K). The net transfer can also be found by a comparison of private and social profits (D-H).

Through PAM, it is possible to calculate a set of indicators assessing the profitability and competitiveness of a commodity system. The nominal protection coefficient for outputs (NPCO), the nominal protection coefficient for inputs (NPCI) and the effective protection coefficient (EPC) are indicators that highlight the source and degree of the protection of a commodity system, providing information on the incentives or disincentives in the sector.

A PAM table can also be used to calculate the relative efficiency or comparative advantage coefficients of commodities. The first of such coefficients is the domestic resource cost (DRC), which has been widely used in the literature for this purpose (Fang & Beghin, 2000; Mohanty *et al.*, 2003). The DRC coefficient measures the opportunity cost of domestic resources used in production to add value, both assessed in reference prices. The social cost benefit (SCB) coefficient compares total costs to total revenue which are evaluated at reference prices. Another indicator of measuring competitiveness is the private cost ratio (PCR), which compares the efficiency of the domestic factors in market prices under current policies.

Results

Descriptive statistics of the variables

Table 3 provides a summary of the statistics of the variables used in the analysis. It is important to note that some variables showed wider variation across the farms leading to potential outliers. The mean output of sheep meat in the study area was 140 kg per AU. The minimum and maximum outputs recorded were 71 kg and 295 kg per AU, respectively. The standard deviation output was 40, which showed how much the farmers' differed from the average. In the study area, average feed usage per AU was 1851 kg with a standard deviation of 728.7, ranging between 307 kg and 4065 kg. The average veterinary and vaccination costs per AU were 66 TL with a standard deviation of 66.4 and labour usage per AU was 283 man-hours with a standard deviation of 149.7. The average of the other variable cost per AU was 535 TL with a standard deviation of 658.2. Average animal costs per AU were found to be 623 TL, with a standard deviation of 1341.2. The table also revealed the farms' characteristics that were thought to influence the efficiency. The mean of grazing duration was 214 days indicating that the farmers benefited more from pastures during the year. The average of farmer experience was 26 years. The average herd size per AU was 25 with a standard deviation of 19.1, revealing that there was a high variation among farms in terms of size. The share of rearing the Akkaraman race among the farms was 84.4%. The mean of the share of sheep breeding subsidies received in total gross income was 4.95%, ranging between 1.45% and 11.23%. The mean of the rate of using family labour in sheep breeding was 78.7 with a standard deviation of 25.9, indicating that family labour played an important role especially with respect to small-scale farmers. In the sample farms, 40.9% of sheep breeders were able to access extension services.

Technical efficiency in sheep breeding

The Fig. 2 shows that the estimated mean efficiency in sheep breeding was relatively low at 0.50 and ranged between 0.29 and 0.99. Most of the farms (95.5%) came below the efficiency score of 0.692 and only five farms had a score higher than 0.692.

The results of the maximum likelihood of the stochastic frontier estimation are given in Table 4. Labour, the other variable cost and purchased animal cost for the replacement parameters of the stochastic frontier model were found to be statistically significant. In line with a priori expectation, all parameters, except the other variable costs, had positive values implying that an increase in the input use would also increase the output amount of sheep breeding. The coefficients of the log-linear model indicated factor elasticities with respect to the output value of sheep breeding. Labour significantly affected the performance of sheep breeding by 0.087. This implied that increasing labour by 1% could increase the sheep output value by 0.09%. The animal replacement cost variable was one of the main determinants that increased the output value of sheep breeding. On the other hand, other operating costs demonstrated a negative effect, indicating an out of optimal usage of this input.

Overall, the gamma statistic, γ, was positive and significant at 1%, which indicated that TE was important in explaining the total variability of the output produced.

The inefficiency of sheep breeding can be influenced by several factors including the region of the production unit, grazing duration, farmer experience, sheep race, subsidies, herd size, level of family labour utilized and, access to extension services. The negative value of the coefficient implies that technical inefficiency decreases. Thereby, the inefficiency model in this study showed that subsidy rate in gross income, herd size and, the rate of family labour in total had a statistically positive effect on technical inefficiency in sheep breeding, while the variables of region (Aksaray), grazing duration, farmer

Table 3. Summary statistics for variables used in the study (per AU)

Variable	Province	Mean±SD	Min.	Max.
Output				
Sheep meat amount (kg/AU)	Niğde	133±30	83	198
	Aksaray	148±48	71	295
	Overall	140±40	71	295
Inputs				
Feed (kg/AU)	Niğde	1799±601.7	548	3013
	Aksaray	1914±859.0	307	4065
	Overall	1851±728.7	307	4065
Veterinary and vaccination cost (TL/AU)	Niğde	75±62.7	11	309
	Aksaray	55±69.7	2	364
	Overall	66±66.4	2	364
Labour (man hours/AU)	Niğde	288±157.3	91	709
	Aksaray	277±141.5	72	746
	Overall	283±149.7	72	746
Other variable costs (TL/AU)	Niğde	736±795.9	9	2256
	Aksaray	293±302.5	35	1310
	Overall	535±658.2	9	2256
Animal purchasing costs (TL/AU)	Niğde	378±648.1	0	2879
	Aksaray	917±1825.9	0	8094
	Overall	623±1341.2	0	8094
Grazing duration (days)	Niğde	207±56.6	60	300
	Aksaray	222±54.2	0	300
	Overall	214±55.8	0	300
Farmer's experience (years)	Niğde	27±12.7	4	50
	Aksaray	25±13.8	2	59
	Overall	26±13.2	2	59
Sheep race (Akkaraman: 1; other: 0)	Niğde	0.93±0.3	0	1
	Aksaray	0.76±0.4	0	1
	Overall	0.85±0.4	0	1
Subsidy rate in gross income (%)	Niğde	5.25±2.14	3.08	11.23
	Aksaray	4.60±1.57	1.45	8.11
	Overall	4.95±1.92	1.45	11.23
Herd size (AU)	Niğde	24±17.8	4	70
	Aksaray	27±20.5	1	108
	Overall	25±19.1	1	108
The rate of family labour in total (%)	Niğde	83.0±23.6	36.5	100.0
	Aksaray	73.6±27.7	22.3	100.0
	Overall	78.7±25.9	22.3	100.0
Extension services access (yes: 1; no: 0)	Niğde	0.37±0.5	0	1
	Aksaray	0.46±0.5	0	1
	Overall	0.41±.05	0	1

AU: animal unit. SD: standard deviation. TL: Turkish lira. *Source*: Author's calculation (2018)

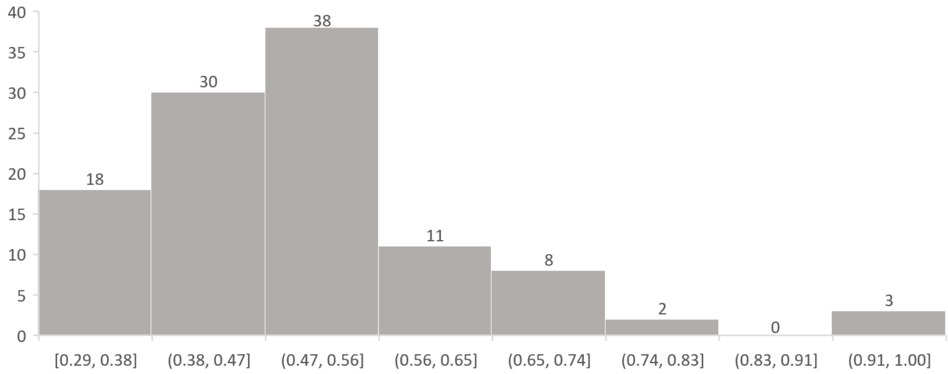

Figure 2. Distributions of technical efficiency scores. *Source*: Author's calculations

experience, sheep race and benefiting from extension service had statistically negative effects on technical inefficiency.

The variables of grazing duration, sheep race (Akkaraman), subsidy rate, herd size and family labour utilized were found to be statistically significant at a 1% level, whereas the variable of region (Aksaray) and access to extension services were found to be statistically significant at a level of 5%.

Competitiveness and sustainability in sheep breeding

The main results of the PAM analysis for sheep breeding in the two provinces and overall farms are presented in Table 5. The PAM results indicated that the policy had an effect per AU. The private profits of sheep breeding were calculated as 1368.67 TL/AU for the overall farms, 1052.61 TL/AU for the farms in Niğde and 1684.02 TL/

Table 4. Model results of stochastic frontier and inefficiency

Variables	Parameters	Estimated value	t-statistics
Stochastics frontier			
Constant	β_0	5.302	10.661***
Ln Feed	β_1	0.010	0.244
Ln Labour	β_2	0.087	1.914*
Ln Medicine and veterinary cost	β_3	0.005	0.272
Ln Other variable cost	β_4	-0.041	-2.211**
Ln Purchased animal cost for replacement	β_5	0.013	6.105***
Inefficiency model			
Constant	δ_0	0.576	1.227
Region (Aksaray province:1; otherwise: 0)	δ_1	-0.073	-2.205**
Grazing duration (days)	δ_2	-0.001	-2.780***
Farmer's experience (years)	δ_3	-0.001	-1.137
Sheep race (Akkaraman: 1; otherwise: 0)	δ_4	-0.220	-4.521***
Subsidy rate in gross income (%)	δ_5	6.052	6.266***
Herd size (AU)	δ_6	0.004	3.095***
The rate of family labour in total (%)	δ_7	0.213	8.769***
Access to extension services (Yes: 1; No: 0)	δ_8	-0.083	-2.264**
Variance parameters			
	σ_2	0.023	6.825***
	γ	0.999	11.596***
Log-likelihood function	—	51.390	—

***, **, *: *p*-values at 1%, 5% and 10% levels, respectively

Table 5. Results of the PAM analysis (TL per AU)

	Location	Revenues	Cost of inputs		PROFIT
			Tradable	Domestic factors	
Private prices	**Overall**	**5983.80**	**2293.28**	**2321.86**	**1368.67**
	Niğde	*5466.27*	*1932.80*	*2480.86*	*1052.61*
	Aksaray	*6529.46*	*2699.06*	*2146.38*	*1684.02*
Social prices	**Overall**	**5483.37**	**3607.09**	**2724.32**	**-848.04**
	Niğde	*5019.97*	*3378.62*	*2563.58*	*-922.23*
	Aksaray	*5971.94*	*3904.93*	*2756.31*	*-689.31*
Effects of divergences and efficient policy	**Overall**	**500.44**	**-1313.81**	**-402.46**	**2216.71**
	Niğde	*446.29*	*-1445.83*	*-82.72*	*1974.84*
	Aksaray	*557.52*	*-1205.88*	*-609.93*	*2373.33*

AU for the farms in Aksaray. However, the negative social profits in the study area revealed that sheep breeding in this area depended on government support. Hence, the farms were not economically profitable or were economically inefficient. The results showed that sheep breeding was privately profitable in the region under the current policies. In general, the results of the PAM analysis showed the effects of the divergences and the efficient policy. Accordingly, due to the supports provided the sheep breeders in the study area benefited from the internal resources at a cheap price. Expenses on the domestic production factors were 2321.86 TL/AU in market prices, which was lower than the level of social prices (2724.32 TL/AU). The same situation was observed with the tradable production factors. The tradable input costs paid by the sheep breeders in market prices were 2293.28 TL/AU, and in social prices were 3607.09 TL/AU. Moreover, the agricultural supports caused an increase in revenues from 5483.37 TL/AU to 5983.80 TL/AU. As a result, there was a transfer of 2216.71 TL/AU from the government to the farmers.

The summary results of the protection coefficients and incentives for PAM are presented in Table 6. Government policies can influence producers, consumers and traders in a commodity system. This influence can be both positive and negative. A PAM analysis can be used to show how government policies influence a commodity system. Nominal protection coefficients (NPCs) show the extent of the divergence of domestic prices from world (social) prices. Such divergences may be a result of the impacts of policies such as trade policies, market imperfections and state agricultural policies. The result of NPCO was equal to 1.09 for both provinces. As its prices were above social prices, sheep breeding was protected by means of support policies. Therefore, the producers received prices that were 9% higher than the border prices. In terms of NPCI, which shows the degree of transfer or the level of protection of tradable inputs, the result was equivalent to 0.57 in the farms in Niğde, 0.69 in the farms in Aksaray and 0.64 for the overall farms.

The EPC ratio shows the degree of the incentives offered to producers from output and tradable input distortions. Sheep farmers in Niğde and Aksaray and the overall farms received much more support for their value-added at the level of 115%, 85% and 97%, respectively.

Table 6. Summary results of the protection and competitiveness coefficients in sheep breeding

Indicator	Niğde	Aksaray	Overall	Efficient farms
NPCO	1.09	1.09	1.09	1.09
NPCI	0.57	0.69	0.64	0.97
EPC	2.15	1.85	1.97	1.30
SCB	1.18	1.12	1.15	0.80
PCR	0.70	0.56	0.63	0.49
DRC	1.56	1.33	1.45	0.88

NPCO: nominal protection coefficient for outputs. NPCI: nominal protection coefficient for inputs. EPC: effective protection coefficient. SCB: social cost benefit. PCR: private cost ratio. DRC: domestic resource cost. *Source*: Author's calculations

The competitive indicators, namely PCR, DCR and SCB, are reported in Table 6. PCR indicates the percentage of the value added used to remunerate the factor of production, *i.e.* the components of the value added. The PCR for sheep breeding was equal to 0.63 overall, meaning that only 63% of the value added was absorbed by the remuneration of the production factors. The values of DRC in both provinces were >1, meaning that domestic costs were in excess of social costs. Therefore, excluding the efficient farms, the sheep farms in both provinces had no comparative advantage. Furthermore, the inefficient use of the country's resources for sheep breeding was higher in the farms in Niğde than in the farms in Aksaray.

Similarly, the SCB value, another indicator of competitiveness, was found to be >1 in both provinces. This indicates that the total input costs were greater than the revenue and sheep breeding was not competitive. However, the SCB value for the efficient farms was found to be 0.80, which shows that these farms were competitive.

In this study, the association between sheep breeding competitiveness and TE was analysed using Kendall's tau_b rank correlation analysis. The correlation coefficients between the TE scores and SCB and PCR were found to be -0.56 and -0.50, respectively, indicating that there was a statistically significant negative correlation between them at a 1% significant level. This finding implied that many farms with relatively high TE scores displayed a better competitiveness degree. However, some of the farms were relatively efficient, but were not competitive or viceversa (Fig. 3). Therefore, the result of the analysis provided some insight into the contribution of TE to competitiveness or vice versa.

Discussion

In developing countries, efficiently using scarce resources by considering the economic and social costs of current policies is extremely important in formulating the appropriate policies to ensure food security and economic development. With this purpose, the present study empirically examined the competitiveness and determinants of the TE of sheep breeding under the current policies at the farm level in the provinces of Niğde and Aksaray in Turkey. Furthermore, it was aimed to investigate the association between these two measurements in order to enable the comprehension of how this information can contribute to explaining sustainability.

Based on the results of the study, it was concluded that sheep rearing farmers were technically far from the efficient frontier. However, without changing the level of input, sheep farms could increase their income by up to 50% by taking into account the factors that caused inefficiency in sheep breeding. The major determinants that decreased efficiency were current subsidies for sheep breeding, herd size and the excessive utilization of family

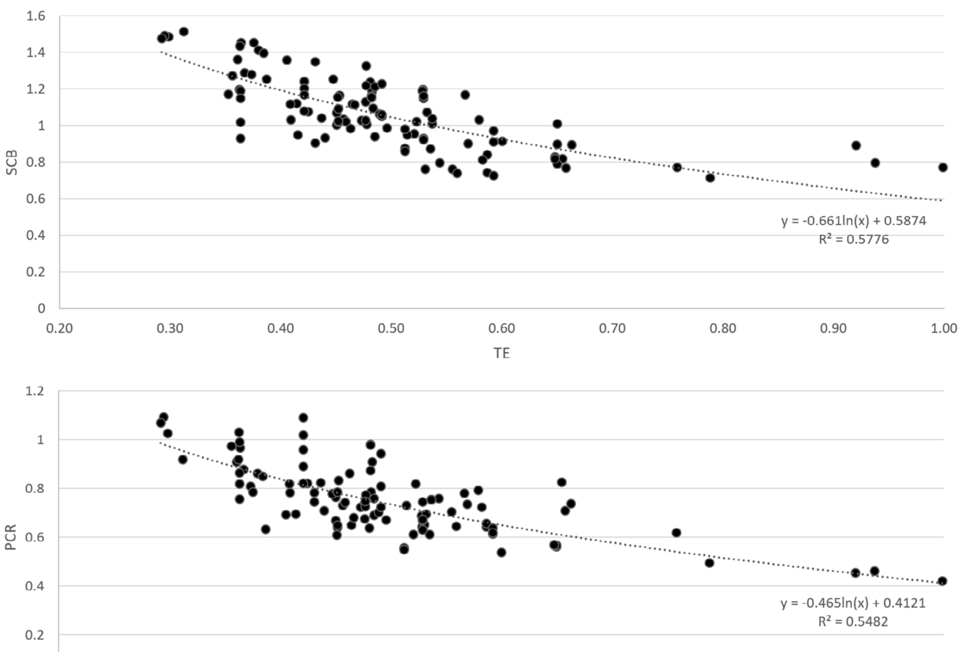

Figure 3. (a) TE (technical efficiency)-SCB (social cost benefit) and (b) TE-PCR (private cost ratio) distributions. *Source*: Author's calculations

labour, while the factors that increased the efficiency were sheep race, access to extension services, grazing period and location. In recent studies, an association between higher subsidy dependency and lower TE of farms has been revealed (Latruffe, 2010; Manevska-Tasevska *et al.*, 2013). The adverse effect of subsidies on TE can be explained by the fact that farmers perceived these supports as an insurance and/or an income aid. Substantive subsidy payments cause farmers to focus on other activities, which may also negatively influence farm productivity (Kumbhakar & Lien, 2010; Manevska-Tasevska *et al.*, 2013).

Contrary to expectations, it was found that there was an inverse relationship between the efficiency and herd size of a farm. The probable reason for this result regarding smaller-size farms can be explained by the possibility of providing a smaller amount of feed at a better quality to animals as well as better looking after animals' health. On the other hand, increasing herd size could be considered as a challenge to improve herd quality rather than a source of inefficiency. This finding was in line with various other studies in the literature (Javed *et al.*, 2011; Gelan & Muriithi, 2015).

The other factor that negatively affected TE was the overuse of family labour. This result can be explained by the extensive use of family labour in small-scale farming due to the nature of such farming systems. This finding was in line with the results of other studies conducted in Turkey (Alemdar *et al.*, 2010; Parlakay *et al.*, 2017).

Sheep race within a herd had an important impact on farm productivity. The farmers in the region mainly preferred the Akkaraman race. This can be related to the fact that farmers were satisfied with the productivity of the Akkaraman race under hard agro-ecologic conditions, as this race of sheep are able to benefit from the poor pastures of the region.

Furthermore, the farmers' access to extension services also had an increasing effect on TE. This result was expected, as agricultural extension plays a very important role on transforming new technology and knowledge into agricultural productivity. This finding was in line with the findings of Li & Li (2011) and Lampach *et al.* (2018).

Grazing duration was another factor that positively affected TE. The pasture were high in nutritional value as they include a wide variety of forage. The pastures also have an economic value as they reduce feed costs. Roughages and pastures, in particular, have an important place in meeting the nutritional needs of sheep. However, the short grazing period in the pasture and the low nutritional value due to vegetation prevent the desired yield from the animals.

Sheep breeding in Aksaray tended to be relatively more efficient than in Niğde. This result was also in line with the findings of the PAM analysis of the study. However, both provinces, in parallel with the country's development in sheep breeding, had recently lost their leading position in sheep production even though they had a long tradition of sheep rearing and potential for small ruminant rearing.

As a result of the PAM analysis, it was determined that sheep breeding was subsidized and protected by the government. However, this implied that the market was at a higher degree of imperfection to ensure sustainability of this activity. In addition, in all research areas, social profits had negative values, which showed that sheep breeding cannot survive without distortion policies. According to the positive net transfers, resources were transferred into sheep breeding from other sectors of the economy. The positive divergences between private and social revenue indicated that due to distortions and market failures, the value of live sheep in the domestic market was higher than world prices. Similarly, the domestic factor transfer was calculated as negative. This implied that the opportunities of non-tradable factors were higher than their market prices. As a result of the PAM table, it can be said that the farmers made a profit from sheep rearing with the existing policies.

Moreover, the differences between the private and social costs of tradable inputs showed that domestic producers were supported by cheaper input price levels compared to world prices. According to the NPCI, there was an income transfer from society to farmers, as the costs of tradable inputs had been reduced by the distortions of policies, *i.e.*, the inputs were subsidised and protected by import tariffs. The average domestic prices for these inputs were only 64% of the world prices in the study area.

To capture the influence of government policies on sheep breeding by considering both input and output markets together, the EPC was calculated. As a result, it was found that there was a net incentive of 97% for sheep rearing farmers in the study area. However, while this net transfer from society acted as an incentive for farmers to stay in farm activities, it constituted a net cost to the government that, through tariffs and subsidies on imported feeds, sustained its domestic price and reflected on an increase of the cost to citizens in general, through the generation of negative health and environmental externalities. It should be noted that this value was only 30% for the efficient farms.

In addition to the protection level of farm activities, the DRC, PCR and SCB coefficients showed the competitiveness level of sheep breeding. A value higher than 1 for the DRC implied that current government policies on sheep self-sufficiency caused significant allocative inefficiency and inefficient use of scarce resources. On the other hand, if farms used their resources efficiently, this value decreased to 0.88, implying that the efficient farms had a comparative advantage.

The PCR values, which were <1 for both provinces, showed that farmers enjoyed positive profits and were likely to be motivated to stay in sheep breeding. This value was the lowest in Aksaray at 0.56 meaning that only 56% of the value added was absorbed by the remuneration of the factors of production. The remaining 44% represented the extra-profits gained by the farmers. However, this coefficient for the efficient farms was calculated as the highest extra-profits by up to 51%. Conversely, the result of the SCB coefficients in these areas were >1, indicating that these values were consistent with the DRC results. The other farms, excluding the efficient farms, were not competitive in sheep breeding.

In conclusion, the policies implemented could only just ensure the survival of this sector and not ensure to increase the competitiveness on both national and international levels. The results indicated that if the farms worked under efficient conditions, the region could have a comparative advantage in sheep breeding. Therefore, the implementation of structural supports in the long term, which may enhance the efficiency of farms, have substantial importance in ensuring the sustainability and competitiveness of the sector. With this regard, the major obstacle in the improvement of the small ruminant sector in Turkey as well as the region is the utilization of pastures. As pastures have not been protected nor been improved for years, roughage production has declined and livestock producers have turned to compound feeds to compensate (FAS, 2018). Furthermore, sheepherding no longer appeals to young people, which causes increases in migration from rural to urban areas in order to achieve higher life standards. For this reason, practices that encourage intensive small ruminant farming by providing sufficient income should be the objectives of agricultural policies. As a result of increase in the importance of small-scale farms around the world, policymakers should focus on the inclusion of small-scale sheep breeders into the market. Moreover, to increase productivity, researches related to genetic improvement and innovation should be continued and the results should be introduced to farmers through extension services. The main limitation of this study was that owing to time and financial constraints, the study area was restricted to only two provinces. Thus, further research is needed to make cross-region comparisons covering the whole country.

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