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The future of transhumant farming: An economic analysis of management characteristics of transhumant Greek farms

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Abstract: *Transhumance is a type of pastoralism, constituted by the seasonal migration of livestock between mountainous pastures and lower altitudes, common in all Mediterranean countries. The objective of this paper was the measurement of the efficiency of transhumant farms across the country as well as the identification of management practices or producer's characteristics that effect their efficiency. The necessary data were collected from 551 transhumant farms via an appropriately structured questionnaire. Data Envelopment Analysis and subsequently regression analysis was performed to identify the impact of management and personal characteristics on the efficiency of the farms. Results revealed that the average technical efficiency of the transhumant farms was quite low, mainly attributed to a manifold degree of mismanagement of the available inputs. In addition, several managerial characteristics, such as the kind of the reared animals, the herd size, the distance that herds traverse and lactation, as well as personal characteristics of the producers, such as their educational level had a significant effect primarily on the* technical and to a lesser extent on the scale efficiency.

I. Introduction

Transhumance is an extensive farming system developed by livestock farmers, that moved their herds between lowlands and uplands, in order to cope with the seasonality of the available forage, contributing to botanic, wildlife and local breed genetic diversity, being also socially and cultural suitable and beneficial to rural development (Luchinger 2003, Siasiou *et al.*, 2018).

Extensive farming however during the last decades are apace changing, forced by the increasing demand for meat and milk due to the increase of human population, the economic progress and the higher standard of living. These forces are linked with the intensification of production depicted on the adaption of "advanced" management practices and the subsequent accretion of production per animal. Indicative of the intensification

of extensive system in Greece is the fact that the 40% of the mountainous pastures are undergrazed (Caraveli *et al.*, 2000).

The purpose of this paper was to measure the technical efficiency of transhumant farms across North and South Greece and to identify the ability of the farmer to ensure maximum output that premises optimal management and utilization of inputs. Based on the economic data of 551 transhumant farms from all the regions of the country, Data Envelopment Analysis (DEA) was performed to measure the technical efficiency (TE) and scale efficiency (SE) of the transhumant farms. Subsequent regression analysis was performed to identify the management practices that can lead to higher level of efficiency. In the literature the measurement of efficiency has mainly been focused on more intensive management of livestock, such as dairy cattle farming (Johansson *et al.*, 2007; Hansson *et al.*, 2008; Vlontzos and Pardalos, 2017) intensive sheep farming (Theodoridis *et al.*, 2012) and swine production (Galanopoulos *et al.*, 2006). Extensive type of farming has been studied by researchers such as Fousekis *et al.* (2001), Perez *et al.* (2007) and Toro Mujica *et al.* (2011), while Galanopoulos *et. al.* 2011 studied the efficiency of transhumant farming system in a region of Greece.

II. Materials and Methods

The survey covered a random stratified sample of 551 transhumant sheep and goat farmers. Data were obtained through individual interviews conducted by trained enumerators by means of an appropriate structured questionnaire that included questions about the performed managerial practices of the herders as well as the performance characteristics of the reared animals. Questionnaires were administrated to herders to South and North Greece as well and enumerators visited the farmers in their place of residence (either summer or winter domiciles). Because of the complexity of the questionnaire each interview lasted for 60 minutes on average.

2.1 Technical efficiency

The measurement of technical efficiency can be performed by two general approaches, the parametric and the non- parametric. The non-parametric approach involves linear mathematical programming and create a non-parametric frontier over data so that all observations or Decision-Making Units or DMUs lie on or below this frontier (Charnes *et al.*, 1978; Latruffe *et al.*, 2005). DEA has two different orientations, i.e. the input and the output. The former estimates the proportional decrease in the use of inputs for a certain level of output; while the later the proportion of maximization of outputs from a given set of inputs (Farrell 1957; Coelli *et al.*, 2005). In the current study, an output-oriented model was more suitable given the character of transhumant system that is sufficiently exploiting nature's resources and input level is already limited.

2.2 Model formulation

The DEA model is comprised of three outputs and five inputs (Table 1). Outputs include the produced milk per female (kg), the produced meat per female (kg) and other sources of income (i.e. sale of cheese, yogurt, wool and other agricultural, excluding EU subsidies) and five inputs. The inputs used in the model are (i) the nutritional cost (ii) all other variable costs (health, reproduction, agriculture expenses and expenses originated by the occasional use of foreign labor, such as the expenses of the transportation of the animals, the removal of manure etc.); (iii) working hours (iv) machinery maintenance expenses; (v) land use expenses (rent of grazing land and harvest expenses). All variables have been normalized by the number of (female) animals.

Subsequently, using the DEA efficiency scores as dependent variable *Tobit regression* was performed in order to investigate the impact of personal aspects and management choices of the producers on technical efficiency of the farms.

The combination of DEA and a two-step regression is common in the relevant literature (e.g Galanopoulos *et al*., 2011; Toro-Mujica *et al*., 2008).

The personal characteristics of the producers that were used in the regression analysis were:

- *the educational level* of the producers (0 for elementary; 1 otherwise)
- *cause of engagement* with transhumant farming system (0 for family environment influence (i.e. family succession; 1 for personal choice)
- *The succession potential,* i.e. the existence of a family member that will take over the farm in the future

The management practices taken into consideration were:

- The *kind* of the reared animals (0 for sheep and 1 for goats). For mixed type of herds, the kind of animal that was reared in majority was taken into consideration.
- The *breed* of the animals (0 for cross-breeders with dairy breeds, i.e. being Greek or foreign dairy breeds or pure dairy breeds and 1 for pure local mountainous breeds).
- *Herd size* (total number of reared animals)
- *Distance* between winter and summer domiciles measured on km
- *Lactation*, measured on days

Furthermore, parametric analysis was conducted between measures as the sample was normally distributed, while x^2 and Kruskal-Wallis tests were used to reveal differences in means of TE and SE scores across farmers in the two studied areas.

Table 1 *Descriptive Statistics Of The Variables Used In The Model.*

Variable	Unit	Mean	St. Dev
Milk	Lt per head	97.45	103.61
Meat	Kg per head	18.42	28.65
Rest sources of income	Euros per head	8.86	46.69
Nutrition Cost	Euros per head	75.18	47.06
Rest variable cost	Euros per head	19.87	24.24
Labor	Euros per head	19.03	14.42
Expenses of fixed capital	Euros per head	60.71	86.47
Expenses of land	Euros per head	12.41	14.26

III. Results and Discussion

3. 1. Technical efficiency scores

In table 2 the mean TE scores are presented. Results reveal large variations in farm level technical efficiency and ample space for efficiency improvements; on average, under VRS, farms can achieve as much as 35.9% increase of output with the same levels of inputs. Scale efficiency scores also vary significantly, ranging from 0.289 to 1, while 53.5% of the farms (295) operate under decreasing returns to scale (DRS), 30.7% (169) under increasing (IRS) and only 15.8% (87) are scale efficient, i.e. they operate under the optimal size and use the best practices available.

Table 2 *Summary Statistics of The Efficiency Results.*

	Mean	StD	Max	Min
TEcrs	0.585	0.251	1	0.105
TEvrs	0.641	0.252	1	0.124
SE	0.910	0.128	1	0.289

The findings of this study are generally in accordance with previous studies on transhumant farming systems in Greece, such as Galanopoulos *et al*. 2011 who recorded scores of TE 0.48 of transhumant farms in West Macedonia, when subsidies were considered and TE 0.51 without. Still, they appear to be lower than the results obtained from studies focusing on extensive sheep and goat systems generally. More specifically, Fousekis *et al*. 2001 derived an average TE score of 0.89 for sheep and goat farms located in mountainous and semi mountainous areas while other studies in different countries exhibited also higher TE scores: Gaspar *et al.* 2009 (TE 0.86 with subsidies and TE 0.851 without), Perez *et al.* 2007 (TE 0.66) and Latruffe *et al.* 2005 (TE=0.74).

In an attempt to identify potential sources of efficiency variations amongst transhumant farms in Greece, the techno-economic data of production data (i.e. revenues and expenses) were further analysed by breaking down operational data and identifying four group of farms relative to their TE scores (Table 3). It can be seen that as fixed cost decrease, farms become more technical efficient; fixed cost is 37% lower for the technical efficient

farms compared to those that had TE scores below 0.6. In total, the production costs are around 26.70% lower for the technically efficient firms (134.17 to 183.53 €/female).

In addition, technically efficient farms generate considerably higher revenues, as much as 70% (92.70 to 158.02 €/female) more than the least efficient farms. More specifically, all sources of revenues - but milk - are higher as TE increases. Revenues generated from meat sales are around 213% higher and those from other sources are 330% higher for the fourth (i.e. technical efficient) group compared to the first (i.e. least technical efficient). Interestingly, revenues from milk production is higher in the second group (0.60-0.79). This particular group is comprised of farms that have high revenues (second only to the technical efficient group) but also exceptionally high production costs (higher even than the least efficient group of farms).

Statistically, the synthesis of production costs and of sources of income between the most and least technical efficient farms is significantly different in nutrition (t=2.11, p=0.036), rest expenses (t=-2.27, p=0.024), fixed cost (t=-2.53, p=0.012) and cost for land (t=-2.21, p=0.001), as well as for all revenues, i.e. milk (t=2.11, p=0.036) and meat (t=3.25, p=0.001). Misallocation of inputs and resources, along with poor management practices have a considerably high impact on the economic performance of transhumant farms.

Table 3. *Financial Breakdown of Transhumant Farms Per Levels Of TE*

Euros /♀	**<0.6**	**0.60-0.79**	**0.80-0.99**	**1**	**TE=0.641**
Sources of income					
Milk	75.50	**122.92**	114.04	115.40**	97.42
Meat	12.26	20.37	27.23	26.17***	18.41
Rest sources of income	4.94	10.37	10.23	16.45**	8.86
Total gross income	92.70	153.66	151.50	158.02	124.69
Synthesis of the expenses					
Nutrition cost	74.90	85.05	77.46	63.71**	75.16
Labor cost	5.45	6.47	4.91	4.99	5.49
Rest variable cost	**20.38**	**22.61**	**18.59**	**16.48****	**19.68**
Fixed cost	67.54	72.69	42.80	42.52**	60.70
Expenses of land	15.26	11.90	10.31	7.01***	12.41
Total of expenses	**183.53**	**198.72**	**154.07**	**134.71**	**173.44**

***Differ significantly at 1% sig level.

**Differ significantly at 5% sig level.

3.2 Regression scores

A Tobit analysis using the technical and scale inefficiency scores as the dependent variables and "personal characteristics" and "management practices" as the independent, was subsequently conducted. Results of the analysis are presented in table 6. It should be mentioned that the independent variables are the inefficiency scores, hence the negative value of a coefficient reflects a positive effect on efficiency levels and vice versa. Accordingly, the educational level of the producer has a negative impact on TE scores implying that the producers with preliminary educational level were more technical efficient. This result can be perhaps explained by the fact that these producers have been occupied in the transhumant farms from a younger age that makes them more experienced. This finding is perhaps unsettling, but previous literature on the subject is not unanimous: According to Rougor *et al*. (1998) and Hassanpour *et al*. (2012), education has a positive impact on the technical efficiency of the farms, however Wilson *et al*. (2001) studying the technical efficiency of wheat producers in England and Johansson *et al*. (2007) studying the technical efficiency of Swedish dairy farms did not ascertain any impact of education on the efficiency of the production.

The reason of engagement with transhumance appears to have a positive impact on TE scores, thereby implying that the producers that have consciously chosen transhumance as their profession tend to be more technical efficient. The kind of the reared animals had a positive impact on the efficiency of the transhumant

farms indicating that the farms that rear goats (or mainly goats) were more technical efficient, as presented in Figure 4. This result can be interpreted by the fact that goats are generally more adaptive to harsh environments and can utilize more efficiently natural resources. Interesting is also the finding that the transhumant goats in the sample belong mainly to indigenous mountainous breeds and less to cross breeders or improved dairy breeds (Z=-6.038, p=0.000) while transhumant sheep to crossbreeds. Similar results have been reported by Oberholzer *et al.* 2014 who argued that there is an advantage of goat breeding in contrast to sheep and cattle on extensive farming system ought to their adaptability to grazing especially those of indigenous mountainous breeds.

Furthermore, the size of the transhumant herds has a positive impact on TE and SE scores indicating that the larger herds are more efficient. The average farm size of the efficient farms is comprised of 509 animals. This finding appears to be in accordance with other previous studies: Galanopoulos *et al*. (2011) report an ideal average herd size to 700 animals, Latruffe *et al*. (2005), Toro-Mujica *et al*. (2011) and Theodoridis *et al.* (2012) identified a positive impact of herd size on technical efficiency. On the other hand, Gaspar *et al.* (2008) and Fousekis *et al*. (2001) recorded a negative impact of the herd size on technical efficiency.

Lactation appears to have a negative impact on TE scores, which implies that farms comprised by animals that had the longest lactations were less technical efficient. This finding is interesting, because it sheds further light on a previous observation: the farms with the highest milk production had on average a low TE score (0.6-0.79). A possible explanation is that prolonged lactation periods induce supplementation of feed and thereby higher nutrition costs that do not fit well to the extensive character of the most efficient transhumant farms.

Interestingly, the distance between winter and summer domiciles had a positive impact both on TE and SE score. Transhumant farms that make use of larger seasonal movements, benefit from the fact that they reside in more remote areas where fields are usually larger, less affected by human activities (e.g. buildings, structures, pastures, etc) and with less competition for grazing from other species and/or herds. Moreover, highlands with lower density (i.e. animals grazing) are characterized by higher botanical composition and forage productivity than pastures in medium or lower lands while crude protein and Ca percentage is higher (Rochana *et al.*, 2016).

IV. Conclusion

Transhumance is a farming system with a traditional character that has undergone a series of changes in the last thirty years, most notably the intensification of agricultural production and the adoption of new management practices. The purpose of the study was to evaluate the technical efficiency of the transhumant farming sector in Greece and to pinpoint the factors that characterize the most efficient farms.

Results revealed that *"personal characteristics"* such as the farmer's experience and transhumant farming being a personal choice are *the factors that* contribute the most to the improvement of managerial performance. As such, a strengthening of the linkage between transhumant producers, such as the formation of a "transhumant producer's partnership" as proposed by Duncan *et al*. (2013), or even "discussion clubs" where the transhumant farmers would be able to exchange opinions, experience and learn from each other and even form professional advisory boards could be a policy initiative stemming from this finding

Another interesting finding of the study was that intensive farming practices in a transhumant system does not yield increased technical efficiency. Farms with intensive management (depicted by the higher total production costs in Table 5), exhibit quite low TE scores, whereas the most technically efficient farms are the ones with the lowest cost of production, i.e. less expenses on nutrition, labor and/or land). Hence, as a more extensive character proves to be more suitable for this system, a question arises for the farms that invested on land, genetic improvement, and/or nutritional enhancements): Will they remain to this type of farming that demands seasonal movement to uplands or will they eventually dramatically increase indoor periods or even abandon grazing and transhumance altogether? In essence, the future of transhumance is at stake, and it could rely on a recognition of its positive role that contributes to environmental, social and cultural well-being through integrated agricultural policies that support extensive grazing and livestock movement.

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