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EFFICIENCY AND ECONOMIC ANALYSIS OF GREEK BEEKEEPING FARMS

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Abstract

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Beekeeping is an economic activity, not only because of the products it offers, but also for being environmentally friendly. Greece is a significant honey producing country, given its limited population and area. Thus, the present study attempts to perform an important economic analysis of the Greek beekeeping sector, and explore the efficiency of beekeeping farms by applying the Data Envelopment Analysis (DEA) method. According to the results, significant inefficiencies have been identified, despite the fact that beekeeping seems to be a profitable sector. More precisely, beekeepers could achieve the same level of output by reducing their inputs by 34% for the short-run and by 43% for the long-run, on average, given the technology adopted. In addition, the majority of beekeepers should make important changes to their scale of operation. Finally, the reorganisation of the used inputs along with the appropriate adjustments, could lead to the improvement of both: efficiency and economic performance.

Key words: economic results, Data Envelopment Analysis, beekeeping, Greece

Introduction

Beekeeping is one of the few human economic activities that is not only environmentally friendly but also contributes to the rational management of natural resources (Thrasyvoulou, 1998). The most important product of the hive is honey, followed by beeswax, pollen, propolis, royal jelly and bee poison. In addition, the benefits arising from apiculture are multiplied if pollination is taken into account.

Greek beekeepers possess over 1.4 million beehives, which cover 11% of the total European Union beehives and 1.7% worldwide (FAO). Thus, Greece is an important producer of honey in the EU, for it is ranked 6th in the EU-28, covering 8% of the total European honey production, especially if the country's limited population and area are taken into consideration. Moreover, climatic conditions prevailing in Greece favour honey production, while the large variety of melliferous sources enables the production of unifloral nectar honeys (Thrasyvoulou and Manikis, 1995) that have special organoleptic characteristics. These special characteristics have long been appreciated by Greek consumers, for honey has historically been an essential part of the Mediterranean Diet (Saridaki-Papakonstadinou et al., 2006), while Greece has currently the highest per capita honey consumption in the EU-28.

The aim of the present study is to examine the current state of beekeeping industry in Greece and analyse the efficiency of beekeeping farms by using Data Envelopment Analysis (DEA). It should also be mentioned that this study is the first to apply the DEA method in the Greek beekeeping sector. Thus, a field research was performed by the staff of the Department of Agricultural Economics of the Aristotle University of Thessaloniki in order to collect the technical and economic data necessary to realise this study. More specifically, a structured questionnaire was completed by 287 Greek beekeepers, for the period 2008-2009.

Materials and Methods

In 1957, Farrell attempted to bridge the gap between theory and practice in measuring productive efficiency, taking into account that by that time theoreticians defined produc-

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tion functions as the maximum output obtained from a given input, while practitioners estimated average production functions (Aigner et al., 1977). More specifically, Farrell (1957) introduced ways to estimate frontiers or production functions for the description of input-output relationships in a firm, as defined by microeconomic theory (Seiford and Thrall, 1990). Following Farrell's (1957) work, several approaches have been adopted in an attempt to measure production efficiency. These approaches are broadly categorised as either parametric or nonparametric, with stochastic frontier production function being the most popular parametric approach and Data Envelopment Analysis being the most popular nonparametric approach (Sharma et al., 1999; Alene et al., 2006).

Data Envelopment Analysis (DEA) is a nonparametric technique that adopts linear programming models to measure technical efficiency (Reig-Martinez and Picazo-Tadeo, 2004). DEA was first introduced by Charnes et al. (1978), who built further on Farrell's (1957) work by extending efficiency measures that only dealt with single-input, single-output to handle multi-input, multi-output situations (Seiford and Thrall, 1990). This method's main advantage is that it does not require the parametric specification of technology or any distributional assumption for the inefficiency term. However, it is very sensitive to measurement errors, for it considers any deviation from the frontiers as inefficiency (Alene et al., 2006; Coelli, 1995; Coelli and Perelman, 1999; Sharma et al., 1999).

In the context of DEA, technical efficiency is measured for a set of Decision Making Units (DMUs), which represent "peer entities" (Cooper et al. 2000), with common input and output (Charnes et al., 1978). In practice, DEA uses the observed input and output quantities of DMUs to form a production possibility space (frontier), against which the individual DMUs are compared to determine their technical efficiency (Fraser and Cordina, 1999). Moreover, a DEA model can either be input-oriented or output-oriented, with the former improving efficiency by reducing inputs and the latter by increasing outputs using the same inputs (Cooper et al., 2000). In the present study, the input-oriented model was selected, taking into account the specific features of beekeeping, which make it difficult for beekeepers to control the output ratio achieved. It should also be mentioned that under the assumption of constant returns to scale, the orientation selection does not affect the estimated frontier and the efficiency measures (Alene et al., 2006; Coelli and Perelman, 1999).

The DEA model proposed by Charnes et al. (1978), assumes constant returns to scale (CRS), while its mathematical problem is specified as (Coelli, 1995):

$\max_{u,v} (u'y_i/v'x_i)$

subject to:

$u'y_j/v'x_j \leq 1, j = 1,2,...,N$

$u,v \geq 0$

where:

y_i = the output for the i-th DMU

x_i = the input for the i-th DMU

u = Mx1 vector of output weights

M = number of outputs

v = Kx1 vector of input weights

K = number of inputs

N = number of DMUs to be compared

However, the above mentioned problem has an infinite number of solutions. Thus, the constraint $v'x_i = 1$ is imposed, and u and v are transformed to μ and ν, respectively. This formulation of the problem is known as the multiplier form of the linear programming problem (Coelli, 1995):

$\max_{\mu,\nu} (\mu' y_i)$

subject to:

$\nu' x_i = 1,$

$\mu' y_j - \nu' x_j \leq 0, j = 1,2,\ldots,N$

$\mu, \nu \geq 0$

The envelopment form of the problem is derived using duality and is expressed by:

$\min_{\theta,\lambda} \theta$

subject to:

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$\lambda \geq 0$

where:

Y = MxN output matrix

X = KxN input matrix

θ = scalar

λ = Nx1 vector of constants

Furthermore, the linear programming problem must be solved N times, one time for each DMU examined. The value of θ estimated represents the efficiency score for each DMU, and if it is equal to unity it indicates a technically efficient DMU (Fraser and Cordina, 1999).

The CRS model measures the overall technical efficiency, which can be separated into pure technical efficiency and scale efficiency (Theocharopoulos et al., 2009). However, pure technical efficiency can only be estimated if variations in return to scale are allowed (Iraizoz et al., 2003), which is accomplished by the VRS model introduced by Banker et al. (1984). Actually, the VRS model is formulated similarly to the CRS model, by adding the convexity constraint $N1'\lambda = 1$ (Coelli, 1995):

$\min_{\theta,\lambda} \theta$

subject to:

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$N1'\lambda = 1$

$\lambda \geq 0$

where:

$N1 = Nx1$ vector of ones

Finally, scale efficiency is the result of the division of overall technical efficiency by pure technical efficiency, and if it is less than 1, it indicates farms that either over-produce or under-produce, taking into account their size (Theocharopoulos et al., 2009). More specifically, scale efficiency refers to the most efficient scale of farm operation, while a scale efficient farm has the same level of technical and pure technical efficiency (Dhungana et al., 2004).

Results

Profile of the Greek beekeeper

The majority of the beekeepers that participated in the present research are men (97%) between 40 and 50 years old (34%). However, just 10% of them are younger than 30 years old, a fact that, coupled with the high average age of beekeepers, indicates that beekeeping does not attract young people, which could lead to difficulty in the development and the application of innovations in the sector. Furthermore, the average years of education are quite low (10 years), while only 16% of them have ever participated in any kind of agricultural seminar. It should also be mentioned that a high percentage of the sample's beekeepers (36%) are not principally employed with it but have it as a secondary job. Finally, only 8% of them produce organic honey.

Moreover, the main characteristics of the efficient beekeeper were examined. According to the results, his/her age ranges from 40 to 50 years, he/she graduated from secondary school and he/she has been working as a beekeeper for more than 20 years. It should be mentioned that he/she is a member of a society and association, but also participated in economic development programmes. He/she has an average number of 130 beehives and his/her main occupation is beekeeping.

The efficient beekeeper appears to be particularly interested in training programmes on beekeeping, does not employ workers permanently and has not chosen to adopt organic beekeeping. The aforementioned description shows that efficiency is closely related to the years of work and, therefore, experience. This is also confirmed by the fact that the vast majority of beehives have been inherited and probably also the know-how of the past generations.

Nevertheless, it should be highlighted that, according to the study, efficiency comes from beekeepers that value the knowledge acquired by educational and lifelong learning-programmes. Finally, the participation in development programmes and cooperatives also increases the potential of an efficient management and, as a result, for a better economic output.

Technical and economic analysis' results

Primary data of this study were derived from the 3-year research programme implemented by the Laboratory of Agricultural Economic Research of the Division of Agricultural Economics of the School of Agriculture of the Aristotle University of Thessaloniki and was co-financed by the Greek Ministry of Rural Development and Food and European Union in the framework of Council Regulation (EC) No 797/2004, as amended by Council Regulation (EC) No 1234/2007.

Primary data were collected by means of personal interviews with the owners of beekeeping farms. The sampling method that was adopted in the present study was stratified random sampling, using all beekeeping centres all over Greece as subpopulations (strata). Thus, field research was conducted in the following 15 regions (beekeeping centres): 1) Thrace, 2) Kavala-Thassos, 3) Halkidiki, 4) Central Macedonia, 5) Western Macedonia, 6) Thessaly, 7) Central Greece, 8) Pan-Hellenic Confederation of Unions of Agricultural Cooperatives (PASEGES) - Prefecture of Attica, 9) Northern Aegean, 10) Epirus-Aetolia-Acarnania, 11) Western Greece, 12) Peloponnese, 13) Crete, 14) Piraeus-Cyclades and 15) Dodecanese. The research was based on a sample of 287 farms, for the period 2008-2009.

Thus, fixed capital has been estimated as the sum of the value of bee colonies, of machinery capital, including trucks, of beehives and buildings, while variable capital includes bee feeding, veterinary and packaging costs, fuel, electric power and other expenditure. According to the results, 90% of the capital used in beekeeping is variable and just 10% represents fixed capital. Furthermore, the value of bee colonies is the factor with the highest participation in fixed capital, while the requirements in bee feeding cover 30% of the total requirements in variable capital.

As far as labour is concerned, more than 94% of the hours required to fulfil the requirements of beekeeping are covered by family members and only 6% of them are covered by hired labour. The average price that beekeepers receive for the honey they produce is 5.7 €/kg. Gross return principally comprises of the value of honey (89.6%), followed by the value of beeswax (2%), while the rest of the products cover a low percentage of the gross return. Finally, the most important economic results are presented in Table 1.

Data Envelopment Analysis Results

EMS (Efficiency Measurement System) software (Version 1.3) was used to estimate the DEA models. The DEA problem was solved 287 times, one for each DMU included in the research. Thus, three variables, fixed capital, variable capital and labour (family and hired) wages, were used to serve as the inputs for the DEA model, while gross return was used as the output for the model adopted (the way inputs and output were estimated is described in the previous section). The mean values and standard deviation of both the inputs and the output are presented in Table 2.

Overall technical efficiency was computed using the CRS model (Charnes et al., 1978), and is presented in Table 3. Thus, the average overall technical efficiency was estimated at 0.57, which means that farms could on average reduce their inputs by 43%, while retaining the same level of output, if size adjustments are made (long-run). Furthermore, only 3% of the DMUs appear fully efficient in the long-run, while over 60% of the farms exhibit overall technical efficiency less than 0.60. However, given that the overall technical efficiency that is estimated using the CRS model refers to the long-run operation of farms, it does not only require them to change the ratio of inputs they use but also to increase or decrease their scale of operation. Therefore, the VRS model was also ap-

Table 1
Economic results of beekeeping

Economic results	
Gross return, €/beehive	106.0
Production costs, €/beehive	77.3
Profit, €/beehive	28.6
Cost of honey production, €/kg	4.1
Farm income, €/beehive	56.4
Return to capital, %	11.0

Table 2
Mean and standard deviation of input and output values

Variables	Unit of measurement	Mean	Standard Deviation
Inputs			
Fixed capital	€	72 257.95	42 241.74
Variable capital	€	8 453.22	5 769.61
Labour wages	€	5 411.24	4 188.84
Output			
Gross return	€	27 514.53	15 637.98

Table 3
Overall technical efficiency of beekeeping farms

Range of overall technical efficiency	Number of farms	% of farms	Mean overall technical efficiency	S.D. [a] of overall technical efficiency
0.10-0.39	47	16.38	0.33	0.06
0.40-0.59	132	45.99	0.51	0.06
0.60-0.99	99	34.49	0.72	0.09
1.00	9	3.14	1.00	0.00
Total	287	100.00	0.57	0.17

[a] S.D. = Standard Deviation

Table 4
Pure technical efficiency of beekeeping farms

Range of pure technical efficiency	Number of farms	% of farms	Mean pure technical efficiency	S.D. [a] of pure technical efficiency
0.10-0.39	14	4.88	0.33	0.05
0.40-0.59	101	35.19	0.52	0.06
0.60-0.99	148	51.57	0.74	0.10
1.00	24	8.36	1.00	0.00
Total	287	100.00	0.66	0.18

[a] S.D. = Standard Deviation

plied to estimate pure technical efficiency that refers to the short-run operation of farms.

The VRS model (Banker et al., 1984) allows for variations in returns to scale, and the results from its application are presented in Table 4. Thus, the average pure technical efficiency is 0.66, meaning that beekeeping farms could retain their level of output while reducing their inputs by 34% on average, without any size adjustments. Moreover, more than 8% of the farms are fully efficient, according to this model.

Scale efficiency was computed by dividing overall technical efficiency by pure technical efficiency, and was estimated at about 0.86 (Table 5). Therefore, inputs can be reduced by 14% on average if the appropriate adjustments to the farms' scale of operation are made. Furthermore, just 3.14% of the beekeeping farms operate at the optimal scale of operation, while the majority of them (57.1%) have scale inefficiency less than 10%.

In addition, an attempt has been made to reorganise the inputs used by the beekeepers in order to increase efficiency and approach the frontiers estimated by the application of the VRS model, which does not require any adjustment of the farms' scale of operation. According to the results, which are presented in Table 6, less efficient farms (0.10-0.39) could reduce their inputs by about 70%, in order to increase their efficiency without altering their scale of operation and the technology they use. Farms with pure technical efficiency between 0.40 and 0.59 could achieve the same gross return by reducing their inputs by 49%-53%, while more efficient farms (0.60-0.99) could retain their gross return by a reduction of 28%-31% of their inputs, given the technology they use and their scale of operation.

After reorganising and reducing the inputs used by beekeeping farms, the economic results were estimated again. Results show that profit per beehive can increase from 28.6 €/beehive to 41.6 €/beehive in the short-run, without any size adjustments and given the technology adopted.

Conclusions

The aim of the present study was the economic analysis of the Greek beekeeping sector, and the application of Data Envelopment Analysis (DEA) to estimate possible inefficiencies of beekeeping farms. In particular, the research aspired to help beekeepers improve the way they operate, increase their efficiency and consequently improve their economic results.

Despite the fact that results show that beekeeping is a profitable agricultural sector, it continues to employ older and less educated farmers, while one third of them are not principally employed with it. This is a fact worth mentioning, for it can be an obstacle for the renewal and development of

Table 5
Scale efficiency of beekeeping farms

Range of scale efficiency	Number of farms	% of farms	Mean scale efficiency	S.D. [a] of scale efficiency
0.10-0.39	2	0.70	0.35	0.03
0.40-0.59	25	8.71	0.51	0.06
0.60-0.99	251	87.45	0.89	0.10
1.00	9	3.14	1.00	0.00
Total	287	100.00	0.86	0.15

[a] S.D. = Standard Deviation

Table 6
Reorganisation of inputs used by beekeeping farms

Range of pure technical efficiency	0.10-0.39		0.40-0.59		0.60-0.99	
Inputs	Average of inputs used, €	% reduction of inputs	Average of inputs used, €	% reduction of inputs	Average of inputs used, €	% reduction of inputs
Fixed capital	102 422	71%	73 847	53%	67 774	32%
Variable capital	9 664	73%	9 037	49%	7 699	28%
Labour	10 245	68%	5 789	52%	4 605	31%
Output	Average gross return (€) 17 899		Average gross return (€) 24 917		Average gross return (€) 28 511	

the sector. Furthermore, honey is by far the most important product of beekeeping, although it is possible that an increase of the production of other apiculture products could improve beekeepers' economic results.

As far as farm efficiency is concerned, results show that farms inputs' reorganisation can induce significant improvements in the beekeeping sector. More specifically, only 8% of the beekeepers are fully efficient in the short-run, while this percentage is reduced to 3% in the long-run, indicating that 5% of the fully efficient farms in the short-run should change their scale of operation, for they either overproduce or underproduce.

Given the technology they use, beekeepers could reduce their inputs by 34% for the short-run and by 43% for the long-run, on average, while retaining the same level of output. Moreover, it is estimated that the adjustments to their scale of operation could induce a 14% reduction of inputs. Reorganisation of the farms revealed a need for significant reduction of inputs especially for less efficient farms, which if applied could lead to important improvements of both their efficiency and their economic results.

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