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Economic Performance of Quality Labeled Saffron in Greece

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Abstract

The aim of this paper is to examine the economic performance of Greek PDO saffron farms by estimating their technical efficiency with the application of DEA methodology. The survey was conducted in 2012-2013 in the PDO designated area of Kozani in Western Macedonia, which is the only area the product is being cultivated. Data were collected with personal interviews by means of a structured questionnaire, from a sample of 100 saffron farms. Results indicate that average technical efficiency under constant returns to scale is 0.627 in the sample and farms could have achieved the same level of output using 37% less inputs.

Keywords: technical efficiency, Data Envelopment Analysis, Protected designation of origin, saffron

1. Introduction

In the CAP reform 2014-2020, it is widely recognized that the quality and diversity of the EU's agriculture must be maintained, in view of rising demand for products with identifiable characteristics that are linked to a geographical origin, as well as rising demand for traditional products. Both have been distinct trends within the EU in recent years and led to growing farmer participation in the operating quality schemes of PDO (protected designation of origin) and PGI (protected geographical indication) labels (europa.eu/agriculture/quality/schemes, Regulation (EU) No 1151/2012). Farmers expect to benefit from the joint reputation these quality labels can offer and, thus, be able to at least maintain or increase profitability and competitiveness.

Greek saffron is a traditional product cultivated in the rural area of Kozani prefecture, in Western Macedonia and the product has acquired the PDO label since 1998.There are numerous native species in Greek flora but Crocus sativus is the only species being cultivated. The producer cooperative that has the exclusive right to collect, process, package and market all output, has also adopted the quality assurance systems ISO 9002 and safety management system, Hazard Analysis and Critical Control Point, (HAACCP) (www.safran.gr). All labour intensive tasks such as harvesting the flower, drying and sorting the stigmas are performed in a way that is essential for the preservation of its characteristic attributes in colour and scent. This managerial approach helped maintain a comparative advantage and allowed the product to secure a market niche in foreign trade. However, acreage and production has been following a downward trend during the last decade and efforts are being made to halt and reverse it, taking into consideration its uniqueness and the role it can play for rural employment in the particular less favoured region.

Greece is the second largest saffron producing country, with an average output of 4 tons of p.a. during the last four decades, most of which is directed in export markets. Iran dominates the world market with annual quantities of over

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250 tons that meet approximately 90-95 % of world demand, whereas Morocco, India and Azerbaijan, also maintain a sizeable market share. In Europe, besides Greece, Spain and Italy produce smaller quantities and taken as a whole the quality of European saffron is considered superior due to, amongst other things, the drying methods that can guarantee the preservation of the product's quality properties (White Book-Saffron in Europe).

The objective of this paper is to assess the economic performance of Greek PDO saffron farms by estimating their technical efficiency with the DEA methodology. The second section presents the methodology and the empirical model for the estimation of output-oriented technical efficiency. The third section discusses the empirical results and the last section presents the concluding remarks.

2. Methodology

The approach to measuring the degree of firm efficiency in a multi–input and multi–output context is Farrell efficiency and the aim is to look either for a proportional reduction of all inputs without changing the output or a proportional expansion of its outputs, without changing its inputs, Farrell (1957). The firms under comparison have a common underlying technology that is determined by the factors in which the production process takes place and is given by the technology or production possibility set T:

$$T = \{(x, y) \in R_{+}^{n} \times R_{+}^{m} \mid x \ can \ produce \ y\} \quad (1)$$

Taking into account that the underlying production possibility set is often not known, it is necessary to estimate it based on observed data and then in turn to evaluate the observed production of a firm relative to the estimated technology. The assumptions underlying this process are: Free disposability, which means that we can dispose of unnecessary inputs and outputs; Convexity which means that any weighted average of feasible production plans is feasible as well; Rescaling which suggests that some rescaling is possible; Additivity, replicability indicates that the sum of any two feasible production plans is feasible as well.
The input–based Farrell efficiency of a production plan (x, y) relative to the technology T is defined as

$$E = \min\{E > 0 \mid (E\,x, y) \in T\} \quad (2)$$

that shows the maximal proportional reduction of all inputs x that permits us to continue the production of y. In a similar manner, the output–based Farrell efficiency is defined as in equation (3) and indicates the maximal proportional expansion of all outputs y that is feasible with the given inputs x, Färe and Lovell (1978), Bogetoft and Otto (2011).

$$F = \max\{F > 0 \mid (x, Fy) \in T\} \quad (3)$$

The latter approach is the most common one in empirical studies in agriculture and gives the maximum amount by which output can increase given the currently applied technology and the particular use of inputs. Farmers have control over input use and not over produced output, given that a number of exogenous environmental factors like weather, pests, and diseases are uncontrollable variables, Karagiannis (2014).
Data Envelopment Analysis DEA was originally developed by Charnes, et al (1978) and is a decision making instrument based on linear programming that is used to measure the relative efficiencies of a set of Decision Making Units. The DMUs are comparable units, using similar inputs and producing the same output(s). Efficiency is measured on a scale of 0 to 1, where a value of 1 signifies a DMU that is relatively efficient, and a value less than 1 signifies a DMU that is inefficient. In an output-oriented model a DMU that is inefficient can turn efficient by means of a proportional reduction of its inputs while its outputs proportions are held constant. On the other hand in an output-oriented model, an inefficient unit can become efficient via a proportional increase of its outputs, while its inputs proportions remain the same.
A DMU is considered to be 100% efficient only when no input use can be reduced without either decreasing some of its outputs, or increasing some of its other inputs, and none of its outputs can be expanded without either increasing one or more of its inputs or decreasing some of its other outputs Charnes et al (1981). A firm is considered Pareto-efficient if an effort to improve on any of its inputs or outputs will have an undesirable effect on some other inputs or outputs. In view of the fact that the condition for Pareto-efficiency is that a DMU's efficiency score is 1, efficiency and Pareto-efficiency are effectively the same, Emrouznejad and Podinovski (2004).

The Charnes, Cooper and Rhodes (1978) ratio model (CCR) calculates an overall efficiency for the DMU in which both its pure technical efficiency and scale efficiency are aggregated into a single value. The efficiency thus calculated is always a relative measure. The CCR model allows each DMU to determine the set of optimal weights for each of its factors so as to maximise its efficiency. The outcome therefore consists of a set of weights chosen in a way that the efficiency of any other DMU with these weights will not exceed 1, the value with which a DMU is relatively efficient. Charnes et al (1981) acknowledged the difficulty in looking for a common set of weights to determine relative efficiency because DMU's may value inputs and outputs in a different way and as a result adopt different weights. Hence they proposed that each DMU should be permitted to adopt a set of weights which presents it the best possible way in comparison to the other units, Bogetoft and Otto (2011), Seiford (1996).

In that context, efficiency of a farm unit j_0 can be calculated as a solution to the following problem Charnes et al (1978):

$$Max\ h_o = \frac{\sum_r u_r y_{rj_o}}{\sum_i v_i x_{ij_o}} \tag{4}$$

subject to $\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \leq 1$ for each farm, with $u_r, v_i \geq 0$

The efficiency of any farm is obtained as the maximum of a ratio of weighted outputs to weighted inputs subject to the condition that the efficiency of all farms are less than or equal to unity. In this case, y_{rj} are the known outputs and x_{ij} the known inputs of the j^{th} farm and are all positive. The u_r and v_i are the variable weights that will be determined by the solution to the maximization problem and may be positive or zero.

The efficiency of each farm in the reference set of j = l,…,n farms is to be rated relative to the others. Thus every farm that is being rated is assigned an additional subscript '0' (equation 4) and the maximization process gives it the most favorable weighting that the constraints would permit.

We can then proceed by replacing the fractional program in (4) by the following linear form in order to apply the methods of linear programming:

$$Max\ h_0 = u_1 y_{1_o} + \ldots\ldots + u_r y_{r_o} \tag{5}$$

$$\text{subject to} \quad v_1 x_{1_o} + \ldots\ldots + v_i x_{i_o} = 1 \tag{6}$$

$$u_1 y_{1_j} + \cdots . + u_r y_{r_j} \leq v_1 x_{1_j} + \cdots . + v_i x_{i_j} \tag{7}$$

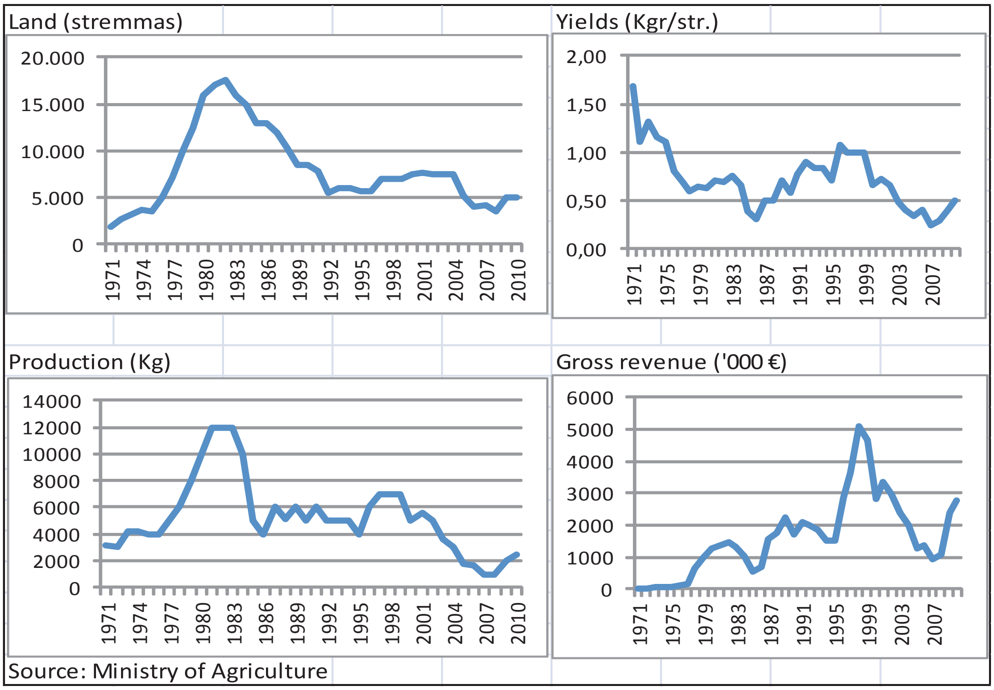
where, $j = 1, \ldots\ldots, n$, $u_1, u_2, \ldots\ldots u_r \geq 0$, $v_1, v_2, \ldots\ldots v_i \geq 0$

The fractional program in (4) is equivalent to the linear form (5) and the optimal values of max $h=h^*$ in the two maximization problems are independent of the units in which the inputs and outputs are measured provided these units are identical for every farm, Cooper et al (2006). The assumption is that farms operate under constant returns to scale. A farm is efficient if $h^*=1$ and there exists at least one optimal (u^*, v^*) with $u^*>0$ and $v^*>0$, otherwise the farm is inefficient.

3. Data-Results

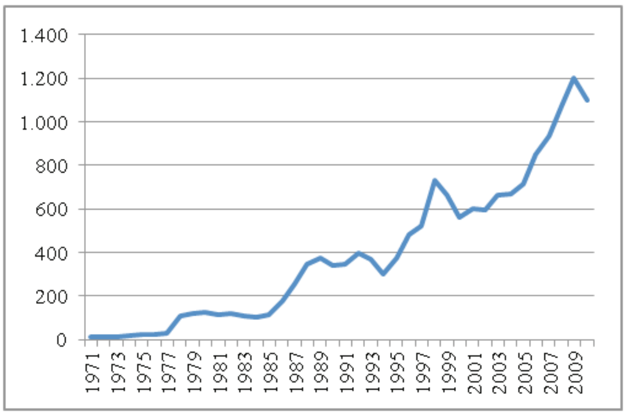
Saffron is a product that has been known and cultivated in the rural area of Kozani since the 17th century. In 1966 farmers formed the first cooperative to increase their bargaining power and to overcome the problem of low prices that were the result of the product's wholesale distribution. In 1971 joint management became compulsory for all farmers and the cooperative took its present name. The establishment of the 'Kozani Saffron Producers Cooperative' marked the beginning of a good decade for this product with production reaching its height record of more than 12 tons in 1982 (Figure 1). Even though participation was enforced to farmers wanting to engage in saffron production, it managed to coordinate cultivation in the area and improve product quality. The cooperative introduced standardization packaging and took initiatives to sustain product quality, (www.safran.gr). Nevertheless, in the period following Greece's accession to the European Community, farmers began abandoning saffron cultivation and turning to other products that were subsidisied. The result was a marked decrease in production which by 1986 reached a low of 4 tons, followed by a period of relative stability, with output fluctuating around 5,5 tons p.a. From 2003 onwards production is declining steadily and in recent years varies around 2 tons p.a. Yields have been following a downward trend over the past four decades, with an average yield of 800 gr/str (1 ha= 10 stremmas) (Figure 1). However, this trend seems to be reversed since 2010 and currently yields vary around 1 ton/str.

Figure 1. Saffron data (1971-2010)



Saffron prices have been steadily increasing over the whole period affording considerable gross revenues to farmers (figures 1 and 2). Current producer price is about 1200 €/Kg with retail price in main export markets like Spain, Italy, France, U.S.A., Switzerland, England, Germany, Scandinavia, The Netherlands, varying from 3 to 14 €/g of red saffron.

Figure 2. Saffron price data (€/Kg) (1971-2010)



Source: Ministry of Agriculture

The survey was conducted in the PDO designated area in Kozani Prefecture (Western Macedonia), which is the only saffron producing region in Greece with cultivation concentrating mainly in the villages, Krokos, Karyditsa, Agia Paraskevi, Ano Komi, Kato Komi, Pefkopigi and Petrana. At present, 700 cooperative members approximately, cultivate an area of about 4,000 str. The sample consists of 100 saffron farms and was selected using the method of simple random sampling. Data were collected with personal interviews by two visiting researchers in 2012-2013 by means of a structured questionnaire. Table 1 includes summary statistics of the input and output variables used for the present study. More specifically, output is measured in terms of total gross revenue per stremma (1 stremma = 0.1 ha) and the unit of measurement is euros. Three inputs are included in the model, labor/str (including family and hired workers) measured in annual working hours, variable costs/str, measured in euros, and capital stock/str expressed in end-of-the-year terms (including machinery and building,) also measured in euros.

Table1: Descriptive statistics of input and output values (€/str)

	Output (€)	Yield (Kg)	Land (str)	Labor (working hours p.a.)	Variable cost (€)	Capital (€)
Average	2134,2	1,7	14,3	144,6	21,6	2514,1
Minimum	1800,0	1,5	4,0	50,3	2,1	166,7
Maximum	2213,8	1,8	40,0	365,7	84,8	7333,3
Median	2205,0	1,8	12,0	141,4	16,8	2364,6
Standard deviation	124,5	0,1	6,9	53,3	19,3	1363,4

Solving the linear programming problem in (5) gave the following frequency distribution of technical efficiencies of saffron farms (Table 2). The average technical efficiency under constant returns to scale is 0.627 which implies that, on average, the saffron farms in the sample could have achieved the same level of output using 37% less inputs. The digression from the efficient frontier may be due to the unproductive farm process in transforming inputs to outputs. There is a considerable variation in relative farm technical efficiencies in the sample, with about a third (32%) operating with below 50% efficiency, about half (49%) in the range from 50-80% and a fourth, with efficiency above 80%. In the sample, 10 farms are found to be fully efficient (h=1), that is, they represent the best existing managerial performance with respect to efficiency. Moreover, from results in table (2), 9 farms emerge having serious technical inefficiency problems.

Table 2: Frequency distribution of technical efficiency of saffron farms

Efficiency Score	Number of farms in range
20-30	1
30-40	8
40-50	23
50-60	19
60-70	16
70-80	14
80-90	6
>90	3
No of efficient units	10
Average	0,627
Median	0,594

Minimum	0,289
Maximum	1,000
Standard deviation	0,195

The inefficient farms in the sample are strictly inefficient compared to all other farms and require managerial adjustments in the production technology. The inefficiency identified with the application of DEA will tend to underestimate rather than overestimate the existing inefficiencies. DEA gives the 'benefit of the doubt' to each farm being appraised, attempting to make it appear as efficient as possible in comparison to other farms, Sherman and Zhu, (2013).

Table 3. Performance of peers

	Peer 1	Peer 2	Peer 3	Peer 4	Peer 5	Peer 6	Peer 7
Labour productivity	17,7	29,5	44,1	32,8	26,8	26,0	27,0
Capital productivity	6,6	1,8	1,2	1,5	1,2	0,9	1,8
Capital/Labour ratio	2,7	16,0	37,8	22,0	22,3	27,5	14,6
Land	15	29	40	27	15	24	29
Labour (hours)	1875	2065	2010	1815	1235	2040	2065
Capital	5000	33000	76000	40000	27500	56000	30200

The DEA program identifies a particular reference farm, which is usually a weighted average of the existing farms and may vary according to which farm is being evaluated. The farms that have positive weights are called peers and DEA identifies precise, existent peers for every evaluated farm. Every time farm j_0 is being assessed, it is projected on the technological frontier where all peers are located. The reference farm and the associated peers are typically understood as the ones that may guide strategic decisions on how farm j_0 can improve Bogetoft and Otto (2011), Coelli et al (2005). The farms that act more often as peers for the inefficient farms in the sample are presented in Table 3 in a descending order, with the first three being the most frequently occurring peers. The first farm that occurs repeatedly as a peer (57 times) has the highest capital productivity, whereas farms 2 and 3 that emerge as peers 45 and 41 times respectively, are superior in labour productivity. The three dominant peers are small (15 str.) medium sized (29 str.) and large (40 str) farms.

4. Conclusions

The EU's agricultural product quality policy has made several instruments available to farmers one of which is the PDO quality scheme that enables them to promote products that have specific characteristics intrinsically liked to a geographical origin. Greek PDO saffron is a traditional product cultivated exclusively in Western Macedonia and is mainly channeled to exports. Saffron production is an important source of income for the region, and because it is a very labour intensive cultivation it offers employment in the local community. The downward trend in the cultivated area and in the volume of production that has been observed during the last decade ought to be discontinued and ways must be found to restore this activity to previous levels.

This paper examined the technical efficiency of a sample of PDO saffron farms employing the DEA methodology and results showed average technical efficiency under constant returns to scale to be 0.627. The transformation of inputs to output seems to lead to a fairly large deviation from the efficient frontier and saffron farms in the sample could reduce inputs by 37% and still manage to produce the same level of output. Three farms have been identified as most frequently occurring peers exhibiting relatively higher capital and/ or labour productivity. The fact that there is no other farm that can operate more efficiently than these three peers, does not mean that all farms, including the peers, cannot be made to operate more efficiently. Farm managers need to address the efficiency of input use and raise capital and labour productivities in order to maintain competitiveness.

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