TECHNICAL AND SCALE EFFICIENCY OF PGI BEAN FARMS IN GREECE

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Abstract
In the EU during the last decade, interest has risen for both consumers and producers in Food Quality Schemes for agricultural products and foodstuffs. For producers, the appeal lies in the benefits associated with the collective reputation of quality that characterizes labels linked to geographical origin. This paper obtained estimates of technical and scale inefficiencies of PGI bean farms in Greece by applying the DEA methodology. The main part of the divergence from the efficient frontier is more due to inadequate use of inputs and less because farms are not operating at the optimal size. The vast majority of the farms in the sample achieved technical efficiency scores in the range of 70–100% and scale efficiency scores in the range of 80–100%. Average technical efficiency is lower than average scale efficiency which means that a larger segment of overall inefficiency is due to producing below the frontier than to operating at an inefficient scale.
Key words: Scale and technical efficiency, Data envelopment analysis, PGI beans, Food Quality Schemes.

Introduction

Participation in the EU Food Quality Schemes for agricultural products and foodstuffs is a way for farmers to maintain competitiveness and profitability via all the advantages collective reputation of quality products can offer. Three widely adopted EU schemes are the following: PDO (protected designation of origin), PGI (protected geographical indication) and TSG (traditional specialty guaranteed). Protected Geographical Indication – PGI is a label for agricultural products and foodstuffs whose production is closely associated with a particular geographical area and at least one of the stages of production, processing or preparation takes place in the defined area. In addition, the product's quality, reputation or other characteristic is essentially attributable to its geographical origin (Regulation (EU) No 1151/2012).

The PGI common bean of Prespes is a protein crop cultivated in the province of Florina, in Western Macedonia, on almost half of the available farmland in an area adjacent to the Prespes lakes. The farmland allocated to bean production in Greece, is 9,062 ha (FAO, 2013) or 0.36% of total arable land which is the highest in the EU-27 for this product. The cultivated area with beans under the Prespes PGI brand accounts for more than a third of that farmland. In addition, it is a very significant source of income and employment in the particular area. Europe has experienced a major reduction in protein crop cultivation from 4.7% of the arable crop area in 1961, to 1.8% in 2011 which was the result of falling demand for such crops for direct human consumption, coupled with increasing demand for livestock products. However, during the last decade developments in the markets changed European farmers who are now interested in protein crops that are increasing in value faster than wheat with which they compete for land. The forthcoming CAP support in the cultivation of protein crops is expected to be a significant influence to the sustainable development of European agricultural and food systems (IP/B/AGRI/IC/2012-067 PE 495.856 EN).

The proliferation of Food Quality Schemes for agricultural products and foodstuffs in the EU has occurred because of the benefits associated with collective reputation, in the form of substantial rents obtained by firms renowned for producing high quality products within such schemes. Tirole (1996), suggested that the better the reputation enjoyed by a group of firms producing under a Food Quality Scheme, the more incentive there is for a particular firm to maintain a level of quality, whereas new-comers at least partially inherit the reputation established by the collective quality brand. However, Winfree and McCluskey (2005) showed that collective reputation can be treated as a dynamic common property resource problem and, in that case, as the number of firms in the group increases, the incentive to supply the same level of quality decreases, when there is no firm traceability. That being so, these firms still profit from high prices because of the added value associated with the quality collective label.

The question that arises in either case, that is whether firms have the incentive to maintain quality or not, is to what extent they are more technically and scale efficient compared to those outside the quality schemes. Sellers-Rubio and Mas-Ruiz, (2014) examined the capacity of PDO labels in the Spanish wine sector to lead to greater firm efficiency while controlling for the role of different characteristics of members such as the average wage paid and the age of firms. They tested the hypothesis that a PDO label has a positive impact on firms' economic efficiency because it is a collective reputation indicator and stimulates efficient investment in quality, using the non-parametric efficiency estimation method Data Envelopment Analysis. Results obtained suggest a low average level of technical efficiency for the whole sample (0.47) but significantly higher average technical efficiency of PDO wineries compared to non PDO wineries. Average scale efficiency is large (0.92) pointing to inefficient use of inputs rather than firms not operating at the optimal size. No statistically significant difference in scale efficiency was found between PDO and non PDO wineries. High scores of scale efficiency (0.97) were also achieved by a large panel of Spanish DO wineries - DO standing for a Spanish label of quality for wines since 1932 - over the period 2008-2010. Average technical efficiency (0.72) is rather stable during this period, but great divergence is detected in the sample with some highly efficient and some highly inefficient firms the latter being the largest in size (Vidal1 et al., 2013). Generally, research results regarding the experience goods of wine and cheese in Spain reveal that PDO brands exert a positive influence on technical efficiency and demonstrate the importance of PDOs in sectors in which firms do not rely on the reputation of individual brands (Sellers-Rubio and Más-Ruiz, 2015).

In the beef sector, Iraizoz et al., (2011) compared two types of beef farms, one under a PGI label and one without any certification, as regards profitability and economic efficiency. Although they find a positive association between PGI production and profitability, PGI beef farms appear less efficient with lower pure technical efficiency scores. The reverse holds for scale efficiency with PGI farms operating closer to optimal size.

Dimara et al., (2005) compares the effects of two alternative quality schemes on farm efficiency, using a sample of Greek black currant producers who either farm conventionally under a PDO label or employ organic methods, and are located either inside or outside the PDO zone. It appears that the location of the farm - inside or outside the designated quality zone - significantly affects technical and scale efficiency of conventional producers. Average technical efficiency for those located inside the zone is lower (0.67) and average scale efficiency is higher (0.77) than the corresponding average estimates for farmers located outside the quality zone (0.79 and 0.703, respectively). On the contrary, no statistically significant difference was found between the two groups of organic farmers. Overall, findings indicate that the contradictory effects of these quality schemes on farm efficiency require policies for organic farming to apply outside the PDO zones.

The objective of this paper is to estimate the technical and scale efficiency of Greek PGI bean farmers by applying the DEA methodology. The rest of the paper is organized as follows: the empirical model for the estimation of output-oriented technical and scale efficiency is presented in the next section. The empirical results are discussed in the third section followed by concluding remarks in the last section.

Materials and Methods

Suppose that we have input-output data for a sample of K farms using the same technology to produce a given output by means of N inputs. Let's further assume that farmers have a control over the different inputs but not over the output they produce due to weather uncertainty. For this reason we follow an output oriented approach to assess their performance, and we are going to estimate by means of the following linear programming problem how much they could have increased their output using the same level of inputs and employing the same technology if they had eliminated technical inefficiency. In terms of activity analysis, the radial Farrell-type output-oriented technical efficiency measure is given by solving for each farm in the sample the following linear programming problem (Equation 1):

$$F_O^k(x^k, y^k) = \max_{\phi,\lambda}\{\phi: \sum_{k=1}^{K} \lambda_k x_n \leq x_n^k \ \forall n, \sum_{k=1}^{K} \lambda_k y^k \geq \phi y^k, \lambda_k \geq 0 \ \forall k\} \quad (1)$$

Where *x* and *y* refers respectively to input and output quantities, λ_k are the intensity variables, x_n are (*1xK*) row vectors of the sample input matrix *X* with elements the quantities of a particular input that are used by the *K* firms in the sample, and *n=1,…,N* is the number of inputs. The restrictions on the intensity variables are related to the structure of returns to scale. The above formulation implicitly assumes constant returns to scale for the whole range of input values and results in what is called the benchmarking technology (Farrell, 1957; Fare et al., 1994).

An alternative specification that restricts the sum of the intensity variables to be equal to one corresponds to a variable returns to scale technology which is referred to as the frontier technology. In this case, output-oriented technical efficiency is estimated by solving for each farm in the sample the following linear programming problem (Equation 2):

$$E_O^k(x^k, y^k) = \max_{\phi,\lambda}\{\phi: \sum_{k=1}^{K} \lambda_k x_n \leq x_n^k \ \forall n, \sum_{k=1}^{K} \lambda_k y^k \geq \phi y^k, \sum_{k=1}^{K} \lambda_k = 1, \lambda_k \geq 0 \ \forall k\} \quad (2)$$

As the convexity constraint related to variable returns to scale is more restricted than the non-negatively of each intensity variable required in the constant returns to scale technology, we have $E_O^k(x^k, y^k) < F_O^k(x^k, y^k)$.

Table1

Descriptive statistics of inputs and outputs values, PGI Beans Farms

	Output (euros)	Land (str)	Labor (annual working hours)	Fertilizer cost (euros)	Pesticides cost (euros)	Irrigation cost (euros)	Capital (euros)
Average	64467	64	2539	2550	2294	1716	53135
Minimum	5632	6	450	262	223,5	162	1000
Maximum	361375	295	7025	9870	9420	8000	153000
Median	37385	40	2050	1807	1599	1100	52000
Standard deviation	60822	53	1589	1951	1794	1425	37841

In addition, one can estimate scale elasticity (Equation 3) using the benchmarking and the frontier based technical efficiency scores, namely:

$$S_O^k(x^k, y^k) = \frac{F_O^k(x^k,y^k)}{E_O^k(x^k,y^k)} \qquad (3)$$

Output-oriented scale efficiency measures the distance to optimal scale after moving a farm to the frontier technology in the vertical direction. It gives the potential output that a farm can produce operating at optimal scale assuming that its technical inefficiency (if any) has been removed. The optimal scale, on the other hand, is determined by the point in the input-output space which corresponds to local constant returns to scale prevails. That point determines by default the maximum average productivity. Elaborating slightly the above relation, we can see that benchmarking performance, i.e., the extent of technical efficiency with respect to constant returns to scale technology, is decomposed into a best practice performance component, i.e., the extent of technical efficiency with respect to variable returns to scale frontier, and a scale component related to the extent of deviation from the optimal scale size. This decomposition provides a useful information regarding the sources and importance of productive efficiency and helps in designing more appropriate policy measures to reduce or even eliminate resource waste.

Results and Discussion

Summary statistics of the variables used for the purposes of the present study are given in Table 1. Output is measured in terms of total gross revenue, measured in euros. Six inputs are included in the production model, namely land measured in stremmas (1 stremma = 0.1 ha), labor (including family and hired workers) measured in annual working hours, fertilizer, pesticides, irrigation cost, measured in euros, and capital stock (including machinery and building,) also measured in euros. Capital stock is expressed in end-of-the-year terms.

Frequency distributions of technical and scale efficiency scores are reported in Table 2. The average

Table 2

Frequency distributions of technical and scale efficiencies of PGI Bean Farms

	Technical efficiency (CRS)	Technical efficiency (VRS)	Scale efficiency
Efficiency Score	Number of farms in range		
30-40	1	1	0
40-50	0	0	0
50-60	1	0	0
60-70	18	5	1
70-80	33	30	5
80-90	33	41	9
90-100	12	13	82
No of eff. units	6	14	7
Average	0.794	0.837	0.949
Median	0.795	0.839	0.975
Minimum	0.395	0.398	0.614
Maximum	1	1	1
Standard deviation	0.112	0.104	0.07

technical efficiency under constant returns to scale (CRS) and variable returns to scale (VRS) are 0.794 and 0.837, respectively. This result implies that, on average, the bean farms in the sample could have achieved the same level of output using 16% less inputs. The average scale efficiency of the sample is 0.949, which means that the largest part of the deviation from the efficient frontier is due to inadequate use of inputs and, to a lesser extent, because farms are not operating at the optimal size. The technical efficiency scores vary between 0.395 for the least efficient farm and 1, for 6 farms which are technically efficient, under constant returns to scale (CRS) and for 14 farms which are technically efficient under variable returns to scale (VRS). There are 7 farms with optimal scale efficiency. The vast majority of the farms in the sample achieved technical efficiency scores in the range of 70–100% and scale efficiency scores in the range of 80–100%. In addition, only one farm in the sample faced severe technical inefficiency problems while nearly 6% were fully efficient farms in the use of existing technology.

Average technical efficiency is lower (0.837) than average scale efficiency (0.949). Thus, a greater portion of overall inefficiency is due to producing below the frontier than to operating at an inefficient scale. As a result, bean farms in the sample could have on average increased their output by 5% if they had adopted the optimal scale and they could have further increased their output by 16% if they had used existing technology more efficiently.

Conclusions

The rising trend in consumer preferences towards agricultural products and foodstuffs of certified quality linked to a geographical origin, along with farmers' interest in the benefits associated with collective reputation, has prompted an interest in the investigation of Food Quality Schemes. Aside from the general interest in the production of such goods for the reasons mentioned above, there is a clear intention from the EU to give greater support to protein crops such as beans and Prespes PGI bean farmers, located in a marginal, less advantaged region, may be expected to expand their activities.

In this paper, estimates of technical and scale inefficiencies of PGI bean farmers in Prespes are obtained using a non-parametric approach. The degree of technical efficiency was found to be lower than the degree of scale efficiency and consequently a greater part of overall inefficiency can be attributed to farms producing below the production frontier than to operating at an inefficient scale. The empirical results suggest that there are no significant scale inefficiencies for the bean farms in the sample given that average scale efficiency is around 95%. Further research is required to look into the specific factors that mainly influence the degree of technical and scale efficiency.

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