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Cost efficiency on organic farming: a comparison between organic and conventional raisin-producing households in Turkey

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Abstract

The paper uses data envelopment analysis to compute overall technical and input-specific technical efficiency measures of conventional and organic raisin-producing households in Turkey. The questionnaires were applied to fourty-four organic and thirty-eight conventional producers determined by stratified random sampling. For each household group the average cost efficiency and technical efficiency coefficients are determined to be 0.712 and 0.862 for organic households, while 0.844 and 0.903 for the conventional group. According to the coefficients calculated for individual and different returns to scale, it can be stated that conventional households are on average more efficient relative to their own technology.

Additional key words: data envelopment analysis, organic farming raisin, vineyard size.

Resumen

Eficiencia de costes en la agricultura orgánica: comparación entre familias productoras de pasas orgánicas y convencionales en Turquía

El documento utiliza análisis de envolvimiento de datos para calcular medidas de rendimiento de técnicas específicas y técnicas de conjunto en familias productoras de pasas orgánicas y convencionales en Turquía. Los cuestionarios se aplicaron a 44 productores orgánicos y a 38 productores convencionales determinados por un método estratificado de muestreo al azar. Mediante el análisis de los resultados por grupos, se determinó que la media de eficiencia por coste y el coeficiente de eficiencia técnica para el grupo orgánico fueron de 0,712 y 0,862 respectivamente, y para el grupo convencional fue de 0,844 y 0,903 respectivamente. Según los coeficientes calculados por individuo y diferentes respuestas de la escala, se puede afirmar que las familias productoras convencionales son de media más eficientes en relación a su propia tecnología.

Palabras clave adicionales: análisis de envolvimiento de datos, cultivo orgánico de pasas, tamaño del viñedo.

Introduction[1]

Almost half of the world grape (*Vitis vinifera* L.) production, 65 million tons in 2004, was obtained in Europe. While Italy has a 13% share in world grape production, France (12%), Spain (11%), USA (8%) and Turkey (6%) follow this country respectively. USA (45%), Turkey (26%) and Iran (13%) are also large raisin producing countries. Productivity shows variations by year, depending on general weather conditions. A great majority of total raisin production has been exported. Total raisin exports realized 643,000 Mg annually during 1999-2003 periods. While Turkey had the greatest share in total raisin exports

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[1] Abbreviations used: AE (allocative efficiency), CRS (constant returns to scale), DRS (decreasing returns to scale), EE (economic efficiency), IRS (increasing returns to scale), MARA (Ministry of Agriculture and Rural Affairs), TE (technical efficiency), VRS (variable returns of scale).

with 203,000 Mg annually, Iran and USA followed this with 118,000 and 108,000 Mg respectively in the same period (FAO, 2007).

Organic grape production has been realized in limited countries in the world. Among these countries, USA, Turkey and some EU countries such as France, Italy and Germany have the most important place. There are 58,100 ha organic vineyards in the USA and 65,000 ha in EU countries (FAO, 2007; USDA, 2007). However, especially in EU countries and the USA, organic grapes are produced towards wine production. Turkey, which have produced and exported organic raisins since 1986, is the world leader in organic raisin production. Raisin exports from Turkey have largely increased over the years. While in 1986 there were few producers and a limited amount of raisin production, now almost 10,000 Mg organic raisins were produced by 900 producers from 2,100 ha (MARA, 2005).

Measuring the productivity of an industry or a production activity is important for policy makers as well as theorists of economics. It is also essential to know whether it is possible to increase the output level of an industry by productivity with no needing extra resources. The scarcity of resources exposes the subject of determining efficiency in the resource use.

While there are plenty of studies comparing the economic performances of organic and conventional farming systems in the world and Turkey (Dabbert and Oberhofer, 1990; White, 1995; Akgüngör, 1996; Klonsky and Tourte, 1997; Kenanoğlu, 2003), it is possible to say that a very complex situation resulted from the fact that the activity results of both production systems were compared in terms of economics.

The results are likely to vary by product and region. However, if a general evaluation was made in light of these research results, organic farming is a production system which has lower productivity per hectare, needs more labour and low energy inputs, follows crop rotation regularly, and has a changing net income level relating with product selling prices.

Therefore, the development of organic methods raise significant research questions related to productivity and efficiency. In spite of the relevance of these topics, literature on the performance of organic farming is still insignificant, primarily due to the relative unavailability of data on organic farms (Oude Lansink *et al.*, 2002).

Above all, little attention has been devoted to efficiency. Studies on productivity (yields, unit costs, etc.) are certainly relevant, but it is the general opinion that efficiency analysis provides more complete information on the convenience or otherwise of adopting organic techniques (Madau, 2005). A comparative efficiency study between organic and conventional farms seems particularly suitable for assessing the farmers' relative ability in optimizing internal resources. Furthermore, the utilization of an efficiency estimation approach is advisable in studies aimed at providing policy indications (Coelli *et al.*, 1998; Madau, 2005).

But, there are only a few attempts of comparing efficiency between organic and conventional production systems. Several studies were conducted by Tzouvelekas *et al.* (2001a,b; 2002a) on Greek agriculture. The authors used a parametric approach to evaluate olive-growing, cotton and durum wheat farms and obtained controversial results. In the analysis on cotton farms, Tzouvelekas *et al.* (2001b) found that technical efficiency (TE), with respect to their specific technology (organic and conventional) was higher in conventional farming's favour. On the other hand, the studies on olive-growing and durum wheat-growing demonstrated the improved ability of organic farmers in minimizing inefficiency (regarding their specific technology).

Oude Lansink *et al.* (2002) compared efficiency measures of organic and conventional farms in Finland. They suggested that organic producers have higher technical and sub-vector efficiencies than conventional farms in their own reference groups, but overall efficiency measures suggest that organic farms are using less productive technology.

In Italy, Madau (2005) applied a stochastic frontier production model and found that conventional cereal farms were significantly more efficient than organic cereal farms, with respect to their specific technology (0.892 *vs.* 0.825), which counter the findings from Tzouvelekas *et al.* (2001a, 2002a). Results showed that 63.7% of the differentials between observed and best-practice output was explained by technical inefficiency for the conventional group, while this value was close to unity for organic farms.

In another recent study, Larsen and Foster (2005) compared efficiency measures of organic and conventional farms in Sweden by a non-parametric technique. Their results indicate that the average efficiency scores of the organic producers are lower than the average efficiency of the conventional producers (0.44 and 0.49 respectively).

Knowledge about input-specific productivity and efficiency differences between conventional and organic farms is important in designing policies to foster productive farming technologies that produce safe food, preserve land and use energy efficiently. Thereby, the objective of the present study was to investigate whether organic and conventional farms differ in terms of input-specific efficiency and productivity.

Material and Methods

DEA model for raisin households

Different methods of obtaining estimates of TE have been suggested in the literature, which broadly can be divided into two groups: parametric and non-parametric. In this study, a non-parametric method was used and is often referred to as data envelopment analysis (DEA). One reason for choosing this method is that a functional form for the production function does not have to be assumed.

Farrell (1957) proposed that the efficiency of a firm consists of two components: TE, which reflects the ability of a firm to obtain maximal output from a given set of inputs, and allocative efficiency (AE), which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure of total economic efficiency.

DEA is commonly used to evaluate the efficiency of a number of producers. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA is an extreme point method and compares each producer with only the «best» producers. By the way, in the DEA literature, a producer is usually referred to as a decision making unit or DMU. Extreme point methods are not always the right tool for a problem but can be appropriate in certain cases.

When using DEA, it is possible to allow for either variable or constant returns to scale (VRS or CRS). The efficiency score of observation *i*, θ_i, is obtained from the following minimization problem (Charnes *et al.,* 1978):

$$\begin{aligned} &\underset{X_i^*,\lambda}{Min}\, w_i^T x_i^* \\ &\text{subject to} \\ &-y_i + Y\lambda \geq 0, \\ &x_i^* - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \qquad [1]$$

where w_i is a vector of input prices for the i^{th} raisin-producing household, superscript T is the transpose function, and x_i^* is the cost-minimizing vector of input quantities for i^{th} raisin-producing household calculated by the linear programming, given the input prices w_i and output level Y_i. $N1$ is a $N \times 1$ vector of I's. The constraint $N1'\lambda = 1$ allows for VRS (Banker *et al.,* 1984). In that case, economic efficiency (*EE*) of the household was calculated by using the equation below, replacing the numerator with the minimum cost of the farm under VRS technology:

$$EE = w_i^T x_i^* / w_i^T x_i, \qquad [2]$$

Here, *EE* is the ratio of minimum cost to observed cost, for the i^{th} household, given input prices and CRS technology. The *AE* was calculated residually by Coelli *et al.* (1998):

$$AE = EE / TE \qquad [3]$$

The computer program DEAP version 2.1 (Coelli, 1996) was used to obtain efficiency scores.

Data

This study was carried out in Aegean Region of Turkey during the production year of 2003-2004. The production of organic raisin on average is 10,000 Mg in Turkey. About 94% of this production is obtained in İzmir and Manisa Provinces, where the number of organic raisin producers is 900. The exact list of all organic raisin producers was obtained from the Research, Planning and Organization Department of Ministry of Agriculture and Rural Affairs (MARA, 2005). On this list, the households having a history of at least three years under organic management were determined (selected households actually ranged from four to seventeen years). In Turkey, while some of the households converted the whole farm into organic farming, the others were inclined to organic agriculture within certain production activities. This situation caused the increasing of sample variance. Therefore, according to vineyard area taken into account, sample size from the population was derived through stratified random sampling. The formula used (Yamane, 1967) was:

$$n = \frac{N \sum N_h S_h^2}{N^2 D^2 + \sum N_h S_h^2} \qquad [4]$$

where N_h is the number of producers in the h^{th} stratum, S_h^2 is the variance of h^{th} stratum, D^2 is the value of $(d/t)^2$, *d* is the quantity of error permitted from the population mean and $t = 1.96$ in response to 95% confidence limit.

The list of conventional producers in the villages where the organic producers were was obtained by field visits. From this population, the sample size of conventional producers was determined by the same sampling method. Each population is divided into two strata with vineyard sizes of 1-5 ha and > 5 ha. A total of forty-four organic farms and thirty-eight conventional farms were determined randomly as sample size. In this study, to compare groups the average group values were taken into consideration.

Accounting records do not exist for the farms in this study. Although the most crucial materials to ensure sufficient and reliable data in agricultural economics research are farm records, data gathered by surveys are also found to be suitable and a dependable method when these records do not exist (Yang, 1986). Data were collected for the 2004 production year via repeated semi-structured interviews with producers and corroborated with farm visits and a review of records of the companies which the crop was sold to.

For the analysis of producer welfare, a partial budget analysis was done (Lampkin and Padel, 1994). Total production costs and the unit cost of product were calculated by adding variable costs with fixed costs such as depreciation, interest, management, maintenance, etc. In calculating interest costs, the interest rate (20%) on agricultural business credit given by the Republic of Turkey Agriculture Bank (T.C. Ziraat Bankasi) in 2004 production year have been taken into consideration.

Productivity was calculated from interviews with farmers. The establishment period and economic life of vineyards were taken as 3 yr and 50 yr, respectively (Erkus *et al.,* 1995).

Results

The descriptive statistics of farm groups are presented in Table 1. Average vineyard size for organic and conventional households was 3.2 and 2.9 ha respectively. The average raisin yield was 3,806.5 kg ha^{-1} on organic households, which is 8% lower than that of the conventional group.

Gross product value obtained from raisins on organic households were 2,081.2 € ha^{-1} and this value was relatively higher on conventional households with 2,126.3 € ha^{-1}. On the other hand, the variable costs per hectare were also higher on conventional households. A *t*-test on the significance of the observed difference between the average variable costs showed that this difference was statistically significant. Net income levels on organic households were higher than that of conventional households.

Table 1. Descriptive statistics of household groups

	Organic		Conventional	
	Mean	SE	Mean	SE
Number of observation (n)	44		38	
Vineyards ha^{-1}	3.2^a	2.8	2.9^a	2.0
Yield of raisin (kg ha^{-1})	3,806.5^a	355.4	4,122.7^a	296.7
Costs and revenues				
Gross product value (€ ha^{-1})	2,081.2^a	175.4	2,126.3^a	170.2
Variable costs (€ ha^{-1})	706.4^a	106.8	1,090.2^b	91.5
Production costs (€ ha^{-1})	1,094.8^a	154.2	1,306.9^b	160.5
Net income (€ ha^{-1})	986.4^a		839.4^a	
Net income per household (€)	3,156.5^a		2,434.3^b	
Inputs				
Labour use (h ha^{-1})	837.2^a	107.4	805.4^a	61.9
Tractor power (h ha^{-1})	61.9^a	16.5	65.9^a	12.2
Farm manure (Mg ha^{-1})	8.1	2.3	—	—
Chemical fertilizer use (kg ha^{-1})$^\#$	—	—	225.1	27.5
Pesticide use (kg ha^{-1})$^\#$	—	—	34.2	5.2

^{b} The mean values of performances for organic and conventional groups are statistically different ($p < 0.01$). $^\#$ In terms of plant nutrition elements and quantity of active ingredients.

Table 2. Efficiency measures in household groups

Efficiency measures	Organic households				Conventional households			
	Mean	Min	Max	SE	Mean	Min	Max	SE
Overall	0.712[a]	0.541	1.000	0.012	0.844[b]	0.688	1.000	0.005
Allocative	0.806[a]	0.687	1.000	0.006	0.934[b]	0.771	1.000	0.002
Technical	0.862[a]	0.686	1.000	0.007	0.903[a]	0.816	1.000	0.003
Purely technical[#]	0.928	0.758	1.000	0.006	0.958	0.879	1.000	0.002
Scale	0.950	0.812	1.000	0.002	0.943	0.877	1.000	0.001

[b] The mean values of performances for organic and conventional groups are statistically different ($p < 0.01$). [#] The technical efficiency devoid of scale effects.

The labour use on organic households was 4% higher than that of conventional households. On average, 438 kg chemical fertilizer per hectare was used on conventional households, which was equivalent to 225.1 kg (N, P, K) in terms of plant nutrition element. Organic households use farm manure extensively.

The efficiency scores for organic and conventional households are presented in Table 2. Regarding economic efficiency, the table reveals that, on average, conventional raisin-producing households are more efficient than organic households (0.844 *vs.* 0.712). This is expected because the organic producers apply a more restricted technology. Since in this study, efficiency scores are calculated as an input-oriented measure, results imply that both farming systems might reduce the production costs.

In addition, a *t*-test on the statistical difference between the average economic efficiency scores in the two samples showed that there is indeed a statistical significant difference in the average economic efficiency between organic and conventional raisin-producing households. Furthermore, the variation of efficiency ratings is much lower in conventional households, as the minimum efficiency score is 0.688, whereas in organic households the corresponding figure is 0.541.

The relative levels of the allocative and technical measures provide evidence as to the sources of deviations from cost minimizing efficiency. For organic producers, the primary source of inefficiency was more allocative than technical. Almost 97.7% of the organic households were inefficient (Table 3). The estimated AE measures varied from 0.687 to 1, with the average of 0.806. The results indicated that organic producers employed an inappropriate input mix and for a given set of input prices faced costs 19.4% higher than the best practice farm in the researched area.

Conversely, for conventional producers, the primary source of inefficiency was technical. The average AE score of conventional households was higher than organic households (0.934 *vs.* 0.806). This implies that relatively more cost savings may be achieved by improving TE rather than AE.

A *t*-test on the significance of the observed difference between the average AE scores showed that this difference is statistically significant.

Estimates of input-oriented TE measures for both farming systems are also presented in Table 2. The estimated TEs for organic and conventional households are, on average, 0.862 and 0.903, respectively. This indicates that organic producers are less efficient than conventional producers, relative to their specific frontier technology. However, it does not indicate that conventional households are more efficient than organic

Table 3. Number of efficient households in farm groups

	Number of efficient households		Ratio of efficient households (%)	
	Organic	Conventional	Organic	Conventional
Overall	1	1	2.3	2.6
Allocative	1	2	2.3	5.3
Technical	7	4	15.9	10.5
Purely technical	18	13	40.9	34.2
Scale	10	6	22.7	15.8

Table 4. The results of returns to scale in household groups

Return to scale[1]	Organic households		Conventional households	
	Number	%	Number	%
IRS	8	18.2	35	92.1
CRS	7	15.9	3	7.9
DRS	29	65.9	—	—
All households	44	100.0	38	100.0

[1] IRS: increasing returns of scale. CRS: constant returns of scale. DRS: decreasing returns of scale.

households to the same degree, because the two production systems are situated on different technological frontiers. It only implies that conventional producers operate closer to their specific frontier than organic producers. According to TE scores, organic raisin-producing households could reduce the use of all inputs relative to their own frontier by 13.8% on average, whereas conventional households could reduce the use of all inputs on average by 9.7%.

The decomposition of the TE measures shows that scale inefficiency was the primary cause of technical inefficiency for conventional producers. Pure TE averaged 0.958 and scale efficiency averaged 0.943, with a SD of 0.001. For organic households, the average scale efficiency score was 0.950.

Almost 15.9% of the organic households were technically efficient. On the other hand, the same ratio was 10.5% for conventional group (Table 3). According to scale and purely TE scores, the ratios of efficient households in organic group were higher than the conventional ones.

Regarding a scale efficiency analysis, 65.9% of total organic households had CRS. This indicated that the output levels of households that had DRS would expand by a smaller percentage than their inputs. Only eight households exhibited increasing returns to scale (IRS), indicating that when these households expand their input levels by a certain percentage, their output levels would expand by a larger percentage. Seven households (15.9% of the total organic households) had CRS.

For conventional households, 92.1% of total households had IRS (Table 4). Furthermore, it is suggested that organic households have DRS and conventional households have IRS. These results were suitable for the aim and structure of each production system. One of the main differences between organic and conventional farming systems is using chemical inputs or not.

Computation of the overall efficiency index allows a global comparison of observed production plans and plans at the frontier, from an input-oriented perspective. For organic and conventional households, average overall efficiency scores were 0.712 and 0.844, respectively, and these figures change little when different vineyard size are considered (Table 5). The interesting finding is that the highest efficiency index is computed for a vineyard size of 2-3 ha for both farm groups (0.791 and 0.879).

In Table 6 the potential cost savings from the elimination of input-oriented TE for the organic and conventional raisin-producers are presented by vineyard size. Since input-oriented measures have a direct cost interpretation, this study's results indicate that a 28.8%

Table 5. Overall efficiency indices by vineyard size intervals

Vineyard size (ha)	Organic households		Conventional households	
	Number of households	Efficiency index	Number of households	Efficiency index
0.1-1.0	6	0.715	5	0.819
1.1-2.0	17	0.675	9	0.832
2.1-3.0	5	0.791	8	0.879
3.1-4.0	4	0.772	6	0.833
4.1-5.0	7	0.721	6	0.834
>5	5	0.695	4	0.861
All households	44	0.712	38	0.844

Table 6. Potential cost savings (conversion made as 1 € = 1.8475 YTL, January 2007) for the organic and conventional raisin-producing households by size

Vineyard size (ha)	Organic households			Conventional households		
	Actual cost	Cost reduction		Actual cost	Cost reduction	
	€ ha^{-1}	€ ha^{-1}	%	€ ha^{-1}	€ ha^{-1}	%
0.1-1.0	711	201	28.3	1,087	198	18.2
1.1-2.0	731	238	32.6	1,116	189	16.9
2.1-3.0	671	143	21.3	1,095	132	12.1
3.1-4.0	666	153	23.0	1,074	179	16.7
4.1-5.0	711	199	28.0	1,069	178	16.7
> 5	678	208	30.7	1,084	152	14.0
All households	706	204	28.8	1,090	171	15.6

reduction in total costs is feasible for organic households whereas a 15.6% reduction is feasible for conventional households. On average potential total cost savings for organic households are estimated to be 204 € ha^{-1}, ranging from 143 to 238 € for different vineyard sizes. The potential cost savings for conventional households were lower than organic households with 171 € ha^{-1} on average. According to our results, the least cost reduction is obtained on households having 2-3 ha vineyard size on both farming systems. However, potential total cost savings in relative terms be smaller for 2-3 ha vineyard size group than the others, households on this group achieved higher efficiency scores (Table 5). Adjusting these values in relative terms as presented in Table 1, an increase of 652.8 € in family income per household is feasible for organic producers with no reduction in output produced by improving their know-how and thus operating closer to their technology frontier (204 € * 3.2 ha).

Discussion

While the empirical results of this study are mostly consistent with previous studies on this subject, a complicated situation exists. First, there is only one study on the same product (Tzouvelekas *et al.,* 2002a). These authors utilize the stochastic production frontier approach in evaluating the TE rates achieved in four types of Greek organic and conventional farm operations, namely, olive oil-producing, cotton, raisin-producing, and grapes-for-wine producing farms. According to empirical results, the average TE scores between two farming technologies are different from each other. For raisin-producing, the TE rates are calculated as 0.7599 for organic, and 0.7004 for conventional group unlike our study results.

In another study, Madau (2005) found that conventional farms were significantly more efficient than organic farms, with respect to their specific technology (0.892 *vs.* 0.825). Larsen and Foster (2005) found that organic producers have a lower average TE which is expected because of restricted technology use. Tzouvelekas *et al.* (2001b) suggested that organic farms exhibit lower efficiency scores *versus* their conventional counterparts in terms of technical and economic efficiency. They found the average TE ratings for organic and conventional groups as 0.7163 and 0.8040 respectively.

On the other hand, Tzouvelekas *et al.* (2001a,b) also found that the average output oriented TE score was higher on organic olive growing and wheat farms. Similar results were found by Oude Lansink *et al.* (2002). They suggest that organic farms are on average more efficient relative to their own technology, but use a less productive technology than conventional farms.

In this study it was determined that the households having vineyard size between 2 and 3 ha were more efficient than the other size groups for both farming systems. Similar findings in the relationship between farm size and efficiency have also been reported by other authors (Hallam and Machado, 1996; Amara *et al.,* 1999) though some studies report contradictory results (Tzouvelekas *et al.,* 2001a; Martínez and Tadeo, 2004).

These analyses suggest that Turkish raisin-producing households have difficulties in implementing organic management practices, as the inferior TE (with respect to conventional techniques) reflects. Also, the decreasing returns to scale that, on average, characterize the sample organic farms indicates these difficulties.

It must be pointed out, however, that the lower TE scores of organic farms should not be interpreted as an advantage of conventional farming system, over organic ones. Since both samples have similar characteristics (size, location, mechanization) these differences may simply mean that organic producers have a restricted technology. Indeed the lower TE matches with the fact that the respective know-how is currently incomplete or experimental, and extension services are largely absent in Turkey.

It is clear therefore that the national institutions should primarily begin to set up conditions for the improvement of the farming technologies for organically produced raisin, coupled with efforts to develop specialized organic marketing channels. Measures aiming improvement of organic farm efficiency should be chosen over the existing subsidization schemes in designing policies for the enhancement of the organic farming system. In order to improve organic farming and increase the welfare of producers, some arrangements for input subsidies used on organic farming should be done and producers should be supported especially in conversion period like in EU countries.

In addition to the productive inefficiencies exhibited by raisin-producing households it is also worth noting that currently there are no established price premiums for the organic raisin; in the sample examined, price premiums given to organic producers were nearly 10% higher than that of conventional producers. This is because established channels for the explicit marketing of organically produced raisin as an organic commodity do not yet exist in Turkey.

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