Comparing the Productive Efficiency of Cooperatives and Private Enterprises: The Portuguese Wine Industry as a Case Study

by
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Abstract

This paper compares the efficiency of cooperatives and private enterprises in the Portuguese wine industry, employing data envelopment analysis (DEA). The use of DEA for the analysis of comparative efficiency within a sector is a key tool in evaluating organizational competitiveness. Competitiveness should be based on benchmarking the different types of organizations that comprise the viniculture sector. We conclude that Portuguese wine cooperatives, on average, are more efficient than their private counterparts. Economic implications arising from the study are discussed.

Keywords: cooperatives, private enterprises, technical efficiency, DEA, wine industry, Portugal

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Introduction

The main purpose of this paper is to apply a relatively new approach to comparing the efficiency of private enterprises and cooperatives operating in the same market. The paper compares the efficiency of private firms with cooperatives in wine-

making industry in order to determine which organizational form is more efficient. The comparison of different organizations is a benchmarking procedure, which is a key issue in economics because competitiveness depends on efficiency. The motivation for the present research is based on theoretical arguments relating to the organization and the industry of which it is a part. The industrial-organization view argues that industrial factors are the primary determinants of a firm's performance (Mason, 1939; Porter, 1980), while the resource-based view argues that the enterprise's internal environment drives competitive advantage (Schumalensee, 1985; Rumelt, 1991). The industrial organization view on performance is based on its measurement at the industry level. However, analysis at the industry level lends support to the resource-based views. If organizations in the same industry, facing identical conditions of supply and demand and operating within the same market structure, perform differently, then resource-heterogeneity among the organizations in the industry is the reason for the differences in results reported in the literature. Research into these competing views in fact reveals strong support for the resource-based view.

On the basis of the above-mentioned theoretical arguments, we investigate whether cooperatives are less or more efficient than private enterprises by performing a sector benchmark analysis of the Portuguese wine producers. We compare cooperatives with private enterprises using financial data for the period 1996–2000 obtained from Dunn & Bradstreet. The research on this issue lends support to the view that cooperatives are the more efficient units in the same market (Singh et al., 2001; Parliament, Lerman, and Fulton, 1990; Lerman and Parliament, 1990). Despite the relative importance of this topic, there is a paucity of research involving comparisons between different forms of ownership operating within the same sector.

The paper is organized as follows. We start with the contextual setting describing the Portuguese wine market in order to establish the framework of the analysis; then we survey the existing literature in order to clarify the contribution which this paper makes with regard to the subject area; this is followed by an explanation of the theoretical framework that underpins the model, a description of the data used, and the results of analysis; the following section compares the efficiency scores of cooperatives and private enterprises, which leads to a discussion of the economic implications of the study and some conclusions.

Institutional Setting

The production of wine in Portugal ranks the country in 5th place among the European wine-producing countries and 11th at the world level (ICEP, 2003). Since

Portugal's accession to the EU, the industry has benefited from strong investment in up-to-date production techniques and technology, bringing about substantial improvement in the quality of its wines. The importance of the sector to the national economy is reflected in the fact that 9% of all agricultural land is devoted to wine production. Approximately half of the estates are smallholdings, with no more than 2 hectares.

The Portuguese wine market is highly competitive and is composed of many organizations, including small, medium, and large private companies as well as cooperatives. The latter account for at least 30% of production and sales. They are represented in the lower- and middle-quality range and exist throughout the country. The high-quality range is controlled by private enterprises. The wine produced by cooperatives is the product of the small landowner-farmers, who deliver their grapes to the cooperative for processing, distribution, and sale. The private enterprises usually have the means to produce their wine themselves. However, some private enterprises buy the grapes of small independent farmers on the market and process them into wine, then bottle and sell the production.

Table 1. Wine Industry in Portugal in 2001

Type	Total number of organizations	Percent
Storage	1,320	15.5
Distillers	604	7.1
Bottlers	984	11.5
Exporters and importers	833	9.8
Wine vinegar producers	8	0.1
Wine sellers without premises	76	0.9
Wine-cellar keepers	130	1.5
Wine producers	1,353	15.9
Vine cultivators	2,700	31.6
Vine cultivators and bottlers	527	6.2
Total	8,535	100

Source: Instituto da Vinha e do Vinho

In 2000, Portuguese wine production, including fortified port and madeira, amounted to more than 6 million hectolitres. Of this, 2 million hectolitres were exported (ICEP, 2003). The main export markets in 2000 for the fortified wines were France, followed by Holland, Belgium, Luxembourg, UK, Germany, and USA. The principal importers of table wines were, in descending order, Spain, Angola, France, UK, Germany, Brazil, USA, Sweden, Denmark and Canada.

The geographical distribution of the production is organized in several wine regions. The Oporto region in the north and, to a lesser extent, the Alentejo region in the centre of the country are the most important on the basis of their production.

In 2001, there were 8,535 wine enterprises registered with the regulatory body, the Instituto da Vinha e do Vinho, and of these 16% were wine producers. Table 1 shows the numbers of registered wine industry organizations by type. It can be observed that the largest category is composed of small farmers who are engaged solely in the cultivation and harvesting of grapevines, before delivering them to cooperatives or private producers for processing into wine.

Literature Review

There is a relative paucity of research into the productive efficiency of different types of organizations. Parliament, Lerman, and Fulton (1990) and Lerman and Parliament (1990) used financial ratios to compare the efficiency of cooperatives with competing forms of ownership in the same market. Other empirical studies in this line of research include Powell (1996), and more recently Singh et al. (2001), who investigated the comparative efficiency of cooperatives using the frontier model.

In this paper, we compare the productive efficiency within a sole industry. We do not consider industry effects, but only organizational unit factors, specifically between cooperatives and private enterprises that compete in the same market. Our findings are generally in line with those of previous studies.

Theoretical Framework

In this study, productive efficiency is determined by data envelopment analysis (DEA). Following Farrell (1957), Charnes, Cooper, and Rhodes (1978) first introduced the term data envelopment analysis (DEA) to describe a mathematical programming approach to the construction of production frontiers and the measurement of efficiency relative to the constructed frontiers. They proposed a model that had an input orientation and assumed constant returns to scale (CRS). Later studies have considered alternative sets of assumptions. Banker, Charnes, and Cooper (1984) first introduced the assumption of variable returns to scale (VRS). Since the model is well established and extensively applied in the literature, its discussion is limited to a brief description. For more details on model development, see Fare, Grosskopf, and Lovell (1994); Charnes et al. (1995); Coelli, Rao, and Battese (1998); and Thanassoulis (2001).

The two scientific methods that quantitatively analyze efficiency, namely the non-parametric DEA and the econometric Stochastic Frontier Analysis (SFA), both have their advantages and drawbacks. Unlike the econometric stochastic frontier approach, the DEA allows the use of multiple outputs. Moreover, since the DEA frontier is estimated with a non-parametric methodology, there is no need to impose any functional form on the data or to make any distributional assumptions for the inefficiency term.

Both methods assume that the production function of the fully-efficient decision-making unit is known. In practice, this is not the case and the efficient isoquant must be estimated from the sample data. Under these conditions, the frontier is constructed relative to the sample considered in the analysis.

DEA is applied to the assessment of homogeneous units, such as wine producers. The unit of assessment is normally referred to as a decision-making unit (DMU). A DMU converts inputs into outputs. The identification of the inputs and outputs in an assessment is as difficult as it is crucial. The literature, data availability, and managers' subjective opinions all play a role in the selection of inputs and outputs. In this paper, the availability of the data drives our choice of the inputs and outputs used in the analysis.

In the programming method, DEA "floats" a piecewise linear surface to rest on top of the observations (Seiford and Thrall, 1990, p.8). The facets of the hyperplane define the efficiency frontier and the degree of inefficiency is quantified by a series of metrics that measure the distances from the hyperplane and its facets.

The general-purpose DEA developed by Charnes et al. (1978) considers n DMUs (j = 1,…, n) using k inputs to secure m outputs. For DMU i, the k inputs form the vector x_i and the m outputs form the vector y_i. Intuitively, we would like to rank the firms by the ratio of all outputs to all inputs $u'y_i/v'x_i$, where u is the vector of output weights, v is the vector of input weights. In practice, the ratio is replaced with n differences for all DUMs (subject to the constraint $v'x_i = 1$), and, assuming constant returns to scale (CRS), we solve the following linear programming problem:

$$\begin{aligned} &\max_{u,v} u'y_i \\ &s.t. \\ &v'x_i = 1 \\ &u'y_j - v'x_j \leq 0, J = 1,2,...,n, \\ &u,v \geq 0 \end{aligned} \tag{1}$$

This is the multiplier form of the linear programming model. Applying the duality principle, we pass to the equivalent envelopment form of the problem, which has fewer constraints and is thus easier to solve:

$$\begin{aligned} &\max_{\theta,\lambda} \theta \\ &s.t. \\ &-y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \qquad (2)$$

Here X is the $k \times n$ matrix of inputs, Y is the $m \times n$ matrix of outputs, λ is a $n \times 1$ vector of constants (unknown), and θ is a sought scalar (it represents the efficiency score of DMU i). For a given set of feasible λ values, the left-hand sides of the input- and output-related constraints specify a production point within the production possibility set (the envelopment hyperplane). The model seeks a point in the production possibility set which offers at least the output levels of DMU i while using as low a proportion of its input levels as possible.

The value of θ obtained in this way is the (CRS) efficiency score of DMU i. The dual problem is solved n times to obtain the efficiency score θ for each of the n DMUs. It satisfies $\theta \leq 1$, with $\theta = 1$ corresponding to a technically efficient point on the production frontier; points with $\theta < 1$ lie inside the production frontier and are technically inefficient.

The CRS problem (2) is modified to allow for variable returns to scale (VRS) by adding a single constraint $N1'\lambda = 1$, where $N1$ is the $n \times 1$ vector of 1s. This convexity constraint produces a convex hull of intersecting planes that envelop the data points more tightly than the CRS hyperplane, so that the VRS technical efficiency scores are greater than or equal to the CRS efficiency scores.

Data

To estimate the production frontier, we used panel data for the period 1996-2000 from 27 wine enterprises, of which 7 were cooperatives. The dataset contained a total of 135 observations. The data were obtained from the Dunn & Bradstreet database of financial reports of enterprises and therefore consisted of financial variables. All the monetary values were deflated by the GDP deflator and expressed in constant 1996 prices.

Output was measured by three financial indicators: sales, value of production, and gross value added (GVA). When choosing the inputs of the DMUs, we in principle have to distinguish between controllable and uncontrollable factors. However, in this study only controllable factors – labor and capital – were available. We accordingly measured inputs by four indicators: labor was measured by the number of workers (full-time equivalents) and by the cost of labor; capital was measured by the book value of the physical assets and by amortization. All inputs and outputs were used simultaneously in the DEA model. This characteristic of DEA to handle simultaneously multiple inputs and multiple outputs is one of its strongest advantages compared with econometric cost or production frontier models. The combination of indicators used in our analysis satisfied the DEA convention that the minimum number of DMUs be greater than three times the number of inputs plus outputs: $5 \times 27 \geq 3 \times (3+4)$ (Raab and Lichty, 2002).

Table 2. Characteristics of the inputs and outputs

Variables	Units	Min	Max	Mean	St. dev.
Sales	Euros	1,000	38,684	35,070	61,517
Production	Euros	1,150	35,360	33,590	55,219
Gross value added	Euros	17	110,322	10,242	18,671
Cost of labor	Euros	121	33,799	23,902	6,447
Full-time workers	Number	4	416	90	101
Physical assets (book value)	Euros	241	390,068	43,505	68,385
Amortization	Euros	27,353	51,009	48,981	20,623

Source: Dan & Bradstreet database of financial reports.

Table 2 presents descriptive statistics of the variables used. There was high heterogeneity among the enterprises in the sample, as is evident from the fact that the value of the standard deviation is higher than the mean for most variables.

Technical Efficiency Results

The DEA index can be calculated in several ways. In this study, we estimated an output-oriented technical efficiency (TE) DEA index, since we are analyzing a competitive market. The hypothesis of variable returns to scale (VRS) was chosen because firm size is a paramount issue in any market. The VRS scores measure pure technical efficiency only. The constant-return-to-scale (CRS) model estimates the overall efficient scores (Charnes et al., 1995). The ratio of overall efficiency

scores (CRS) to pure technical efficiency scores (VRS) provides a scale-efficiency measure.

A wine organization is output-oriented Pareto-efficient if it is not possible to raise any of its output levels without lowering at least another of its output levels, or without increasing at least one of its input levels. The output-oriented technical efficiency of a wine producer is the inverse of the maximum factor by which its output levels could be jointly ("radially") expanded without raising any of its input levels.

Table 3 presents the technical efficiency scores of the wine organizations (private enterprises and cooperatives) from the Dunn & Bradstreet database, which constitute a representative sample of the Portuguese wine enterprises. The rankings are ordered from the most efficient to the least efficient according to the VRS hypothesis. Six DMUs have the maximum technical efficiency of 1 by VRS scores. By overall efficiency (CRS scores), on the other hand, the DEA index is equal to 1 only for two DMUs. All CRS-efficient DMUs are also efficient when VRS is assumed, signifying that the dominant source of inefficiency is due to scale economies. The average efficiency score under CRS is equal to 0.423, including all sources of inefficiency. Thus, the wine organizations could improve their output by 57.7% while maintaining the same input values. The efficiency scores under VRS are higher (0.697) and the loss of output due to inappropriate use of resources – given the scale of operation – is 30.3%. The wine producers are thus observed to be more efficient in managing their resources when the scale of operation is taken into account.

Table 3. DEA Technical Efficiency Scores for Portuguese Wine Enterprises, 1996-2000

	Name	Organizational form	CRS	VRS	Scale efficiency
1	Adega Cooperativa de São Mamede da Ventosa, C.R.L.	Cooperative	1.000	1.000	1.000
2	Adega Cooperativa de Mesão Frio, C.R.L.	Cooperative	1.000	1.000	1.000
3	Caves Aliança, S.A.	Private firm	0.409	1.000	0.409
4	Sandeman & CA, S.A.	Private firm	0.348	1.000	0.348
5	Companhia Geral da Agricultura das Vinhas do Alto Douro, S.A.	Private firm	0.305	1.000	0.305
6	Sogrape – Vinhos de Portugal, S.A.	Private firm	0.277	1.000	0.277
7	Barros, Almeida & CA – Vinhos, S.A.	Private firm	0.386	0.942	0.409

Table 3 (continued)

	Name	Organizational form	CRS	VRS	Scale efficiency
8	Adriano Ramos Pinto, S.A.	Private firm	0.394	0.922	0.427
9	Real Companhia vinícola do Norte de Portugal, S.A.	Private firm	0.615	0.883	0.697
10	Cooperativa Vitivinícola do Peso da Régua, Caves vale de Rodo, C.R.L.	Cooperative	0.519	0.864	0.601
11	Aveleda – Sociedade Agrícola e Comercial da Quinta da Aveleda, S.A.	Private firm	0.301	0.803	0.374
12	José Maria da Fonseca Sucrs, Vinhos, S.A.	Private firm	0.326	0.782	0.417
13	Adega Cooperativa De Murça, C.R.L.	Cooperative	0.641	0.741	0.865
14	Sociedade Dos Vinhos Borges, S.A.	Private firm	0.212	0.674	0.314
15	Manoel D.Poças Júnior – Vinhos, S. A.	Private firm	0.372	0.652	0.571
16	A.A.Calem & Filho, S.A.	Private firm	0.255	0.642	0.397
17	Santos, L.D.A.	Private firm	0.620	0.631	0.983
18	Sociedade Agrícola e Comercial Dos Vinhos Messias, S.A.	Private firm	0.267	0.623	0.429
19	Adega Cooperativa de Arruda dos Vinhos, C.R.L.	Cooperative	0.502	0.601	0.835
20	Caves Primavera, L.D.A.	Private firm	0.380	0.544	0.699
21	Adega Cooperativa de Ponte da Barca, C.R.L.	Cooperative	0.528	0.533	0.990
22	Caves Moura Basto, S.A.	Private firm	0.446	0.465	0.959
23	Adega Cooperativa da Covilhã, C.R.L.	Cooperative	0.406	0.424	0.957
24	Caves da Cerca, S.A.	Private firm	0.289	0.311	0.928
25	Vallegre – Vinhos do Porto, S.A.	Private firm	0.279	0.279	0.998
26	Caves Neto Costa, S.A.	Private firm	0.214	0.259	0.825
27	C.N. Kopke & CA, L.D.A.	Private firm	0.141	0.254	0.556
Mean value			**0.423**	**0.697**	**0.651**
Mean for cooperatives			**0.657**	**0.738**	**0.893**
Mean for private enterprises			**0.341**	**0.683**	**0.566**

Comparing Cooperatives and Private Firms

Having established the efficiency rankings of the Portuguese wine companies, we proceed to test the following hypothesis regarding the relative efficiency of cooperatives and private firms.

Hypothesis: Wine cooperatives are less efficient than private wine firms.

The hypothesis is suggested by theoretical considerations based on strategic and behavioral differences between cooperatives and private firms in the same industry (for more details see, e.g., Parliament, Lerman, and Fulton (1990); Lerman and Parliament (1990)). Differences in organizational incentives may play a role in the differentiation of cooperatives and private enterprises (Shleifer and Vishny, 1997), although in certain settings market competition may equalize performance between cooperatives and private firms, hiding the impact of different governance structure.

Contrary to the hypothesis, Portuguese wine cooperatives tend to have higher efficiency scores than the privately owned firms (see the means for cooperatives and private firms in Table 3). The non-parametric Mann-Whitney test shows that the difference in efficiency scores is statistically significant at the 10% level for both CRS and VRS scores (the Mann-Whitney test is recommended for the analysis of DEA scores by Brockett and Golany (1996) and Grosskopf and Valdamanis (1987)). The test thus rejects the hypothesis and suggest that cooperatives are more efficient than private enterprises in the Portuguese wine market. This result partially supports previous findings for cooperatives in the same sector of activity, viz., Singh et al. (2001), Parliament, Lerman, and Fulton (1990), and Lerman and Parliament (1990). However, this result should be interpreted with caution, because of the low level of statistical significance of the test.

Economic Implications of the Study

A number of points emerge from the present study. First, according to our analysis, cooperatives demonstrate greater efficiency than the privately owned firms, with two cooperatives at the top of the ranking and the others in the middle of the range. The fact that, under VRS, the most efficient units are two cooperatives (Adega Cooperativa de São Mamede da Ventosa, C.R.L. and Adega Cooperativa de Mesão Frio, C.R.L.) signifies that, contrary to the theoretical hypothesis, the cooperative type of organization can achieve high efficiency levels acting in the same market as private enterprises. While this result lends support to the importance of organizational form for performance in a competitive market, it also signifies that

differences in resources, in the form of such factors as wine quality, management team, and distribution networks, may induce cooperatives to achieve higher efficiency than private enterprises acting in the same market (Rumelt, 1991). Good resources are a precondition for enterprises to display efficiency in a given market. In this context we should note that the Portuguese wine cooperatives enjoy better access to resources than private wine producers. The reasons for this are found in the historic roots of Portuguese rural cooperatives in general and wine cooperatives in particular. They were created as associations of small and medium-sized individual farmers in the mid-twentieth century, at a time when the number of private wine producers was small. The members of wine cooperative grow their grapes in good soil and, with the advantages gained by access to established distribution networks, their grapes easily reach the market.

In this context, unique assets are seen as exhibiting inherently differentiated levels of efficiency; sustainable profits are ultimately a return on the unique assets owned and controlled by the wine company, whether it is a cooperative or a private firm (Teece et al., 1997). In addition, the strategic-groups theory (Caves and Porter, 1977), which justifies different efficiency scores on the grounds of differences in the structural characteristics of units within an industry, explains part of the efficiency differences observed in the Portuguese wine industry.

Second, location is a factor contributing to explaining the efficiency, with organizations located in the more highly-regarded wine regions rated as more efficient than those in less prestigious regions, reflecting reputation effects. For example, the two highest ranking cooperatives in Table 3 are located respectively. in Torres Vedras, near Lisbon, a traditional wine region close to the main market (No. 1, Adega de São Mamede da Ventosa), and in the Douro valley, the prestigious port region (No. 2, Adega de Mesão Frio).

Table 4. DEA results for Adega Cooperativa de Murça, C.R.L.

Outputs and inputs	Original value	Radial movement	Slack	Projected value
Sales	28,321	2.321	523	28,846
Production	27,375	1.178	0	27,376
Gross value added	8,372	2.532	0	8,374
Cost of labor	16,931	0	-2931	14,000
Full-time workers	83	0	-5	78
Physical assets (book value)	38,218	0	-11321	26,897
Amortization	17,173	0	0	17,173

Third, although DEA identifies inefficient wine organizations in the sample, it does not identify the cause of the inefficiency beyond scale. DEA identifies the slacks for the inefficient organizations and gives to each a reference set (peer group) which allows for specific recommendations to improve efficiency. Adjustments can be determined in terms of output and input slacks that allow inefficient organizations to move to the efficient frontier. For example, Table 4 shows the slacks for the outputs and the inputs of Adega Cooperativa de Murça, C.R.L. (No. 13 in Table 3). Among the three outputs, sales is the only output with a slack, and it can be increased to the projected value. Among inputs there are slacks in cost of labor, the number of full time workers, and the value of physical assets, signifying that these inputs are used in an inefficient way by the cooperative. The use of inputs with slacks can be reduced and the outputs with slacks can be increased until the DMU reaches the efficiency frontier.

How do the present findings compare with those of Singh et al. (2001)? First, the two papers adopt different methods, therefore a clear comparison is not possible. However, both papers support of organizational importance in cooperative efficiency, which means that efficiency is determined by internal factors specific to the organizations, alongside structural characteristics of units within an industry. Moreover, the organizational differences (cooperatives vs. private enterprises) are possible reasons behind the observed differences in efficiency scores alongside the result of Singh et al. (2001), in which the cooperatives similarly displayed a higher level of efficiency. In the present paper, some, but not all of the cooperatives have been found to have greater efficiency than the private enterprises, and therefore, the Mann-Whitney test has a low statistical power.

Considering the results, the economic implications of this study are as follows: firstly, we conclude that the Portuguese wine cooperatives are more efficient than the wine private enterprises. Based on this inference, the leading Portuguese wine cooperatives should maintain their relative level of efficiency, while the less efficient cooperatives should upgrade their efficiency and second, wine cooperatives should benchmark their performance against their private counterparts, and vice versa, in order for the entire industry to upgrade its efficiency along the time. This exercise would enable the under-performing organizations to adopt appropriate, effective managerial procedures to overcome their deficiencies.

Conclusions

This article proposes a simple framework for comparative efficiency evaluation of wine organizations (private enterprises and cooperatives). The analysis is based on a DEA model that allows for the incorporation of multiple inputs and multiple outputs in determining the relative efficiencies. Benchmarks are provided for improving the operations of poorly-performing units. Several interesting and useful managerial insights and implications from the study are discussed. The general conclusion is that, on average, the Portuguese wine cooperatives are more efficient than their privately-owned counterparts. For the non-efficient units, we have identified peer groups among the efficient cooperatives and the slacks that they should adjust in order to achieve the efficient frontier. The result suggests that resources, scale economies, and organizational structure (cooperatives vs. private firms) are major factors in determining a unit's efficiency. More investigation is needed to confirm the present results.

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