Productivity and Quality-Environmental Changes in Marketing Co-operatives: An Analysis on the Horticultural Sector

Emilio Galdeano*, José Céspedes and Manuel Rodríguez***
***Universidad de Almería, Departamento de Economía Aplicada, Spain**
****Universidad de Almería, Departamento de Dirección y Gestión de Empresas, Spain**
Contact: galdeano@ual.es , jcespede@ual.es , mancrd@ual.es

Paper prepared for presentation at the XI[th] Congress of the EAAE
(European Association of Agricultural Economists),
'The Future of Rural Europe in the Global Agri-Food System', Copenhagen, Denmark, August 23-27, 2005

PRODUCTIVITY AND QUALITY-ENVIRONMENTAL CHANGES IN MARKETING CO-OPERATIVES: AN ANALYSIS ON THE HORTICULTURAL SECTOR

Emilio Galdeano[1], José Céspedes[2] and Manuel Rodríguez[2] (*)

[1]Universidad de Almería, Departamento de Economía Aplicada, Almería, Spain
[2]Universidad de Almería, Departamento de Dirección y Gestión de Empresas, Almería, Spain

(*)This research was partially funded by Spanish MCYT and FEDER aid SEC2001-1578-C02-02

Abstract
The object of the present paper is to analyse productivity incorporating quality-environmental changes in marketing co-operatives. Firstly, it reviews competitiveness factors in the current European agri-food market, especially in relation to the fruit and vegetables sector. Secondly, the productivity trend is studied empirically using nonparametric methods (Malmquist indices) and taking as reference panel data of Andalusian horticultural co-operatives for the period 1994-2001. For this purpose productivity is decomposed into technological change, efficiency and quality-environmental change. Additionally, the correlation of these results with other economic variables is analysed. The indicators obtained show a relevant increase in efficiency for the period under study and a high relationship between the results and product quality-environmental improvement.
Keywords: Productivity, quality-environment, efficiency, marketing co-operative, horticultural sector.
JEL classification: D24, Q13, Q21, L15.

1. Introduction

The new conditions in the agri-food market represent new challenges for agricultural co-operatives and are imposing changes in their strategic approach to business, especially given the greater diversity of demand and the increasingly global market.

In the European Union (EU), co-operative entities are responsible for over 60% of the harvest, handing and marketing of agricultural products, with a turnover of approximately 210,000 million euros (General Committee for Agricultural Co-operation, 2000). With such a high profile in the European agricultural model, expectations for attaining sustainable and competitive agriculture lie to a great extent on the co-operative sector's ability to adapt to the new market conditions (General Committee for Agricultural Co-operation, 1999). In particular, production and marketing must meet market requirements (quality improvement, better marketing conditions, production efficiency etc.) and attain a competitive position within the agri-food system, both on the European scale and in the international context.

Particularly the environmental quality and safety of agricultural produce and pollution generated by agricultural production promise to play more influential roles in OECD (Organisation for Economic Co-operation and Development) countries in both domestic and foreign trade (Carpentier and Ervin, 2002). Recent analyses within the EU show greater diversification of demand due to a larger number of products for consumption. These products differ not so much in terms of nutritional composition, but due to the introduction of components related to health and other values added to the product, which are increasingly linked to quality-environmental factors (Estruch, 1994). These factors, therefore, play a major role in differentiation strategies and the creation of value in agricultural co-operatives.

Product quality is usefully described as a bundle of attributes that determine the product's performance (Caswell and Mojduszka, 1996): Food safety, nutritional value, package, presentation and, to an increasing degree, environmentally respectful production. We use the term "quality-environment" considering the characteristics of the sector under analysis.

In the case of European Union (EU) sector of fresh fruits and vegetables (which represents approximately 40% of final agricultural production) the Common Agrarian Policy (CAP) has been fostering investment in quality improvement, especially since the 1996 Common Market Organisation (CMO). These investments are considered key factors for the marketing of the products, and are included in the so-called Operative Programmes of the farming/marketing co-operatives.

In general, the quality-environmental factors and the current characteristics of the agri-food market are bringing about a change in both the organisation and functioning of co-operatives, which are aiming more at competitiveness. Some authors have used the term “entrepreneurial revolution” to denote this change (Nilsson *et al.*, 1997). On the whole, tendencies and strategies can be observed which are aimed at quality differentiation, innovation, investment in technology and human resources, productivity or capitalisation. Recent years have also seen a number of studies related to the adaptation process of the co-operative sector (Hakelius, 1999; Fulton and Sanderson, 2002; Ménard and Klein, 2004). Analyses of productivity have been applied to co-operative entities (Ferrier and Porter, 1991; Ariyaratne *et al.*, 1997; Kawamura, 1997; Hughes, 1998; Kondo and Yamamoto, 2002, amongst others) in order to assess the suitability of certain sectors to the increasingly competitive scenario. Also, the relationship between quality-environmental management and factors of competitiveness in horticultural firms has been analysed recently by Céspedes and Galdeano (2004).

This work aims to analyse the total productivity change including a quality-environmental factor in marketing co-operatives, taking the fruit and vegetable sector of Andalusia (South of Spain) as a reference. The method used is nonparametric input-oriented Malmquist indices of productivity (Färe *et al.*, 1992; Färe *et al.*, 1994) providing a decomposition of change into technological, efficiency and quality-environmental indices. Our study focusses on the Andalusian horticultural sector (representing 50% of final agricultural production in the region) for two reasons: firstly, as a result of the major role of co-operatives in this sector, accounting for 60% of marketable production; secondly, the sector’s increasing investment in quality and environmental-friendly practices in recent years (Andalusian Council for Agriculture and Fisheries, 2002).

The paper is structured as follows. The following section reviews the current challenges facing co-operatives in the agri-food system and the relevance of quality-environmental factors. The third section outlines the methodology used. The sample of data and variables used are described in the fourth section. The fifth develops a discussion of the results obtained in the analysis. Finally the main conclusions are highlighted.

2. Review of the Current Challenges Facing Agricultural Co-operatives

2.1. Competitive Factors in the New Agri-Food System

Fast-moving technological innovation, growing and globalised competition, and changes in consumer values and habits, among other factors, have been shaping the new scenario in which the co-operatives are immersed. The increasingly competitive environment implies the need to adapt the corporate organisation of co-operative entities. In order to maintain their market position and sustain profitability, they must invest in innovation, quality-environment, human resources and infrastructure. Table 1 reflects some of the current tendencies in the agri-food market.

The new challenges imposed by the current agri-food system are reflected in the following strategies adopted by co-operatives (Nilsson *et al.*, 1997; Fulton and Sanderson, 2002):

- Differentiated marketing (increase in value added) and the tendency towards specialisation (e.g. the search for market niches).
- Increase in planning and direct contracting with distribution centres (vertical integration).
- Provision of more information to producer members and connection with the other agents in the agri-food chain.
- Reduction of the risk as regards price and the development of strategies based on quality management.
- Increase in competitiveness based on technological innovation, economic efficiency and quality-environmental differentiation.

Table 1. Changes in the agri-food sector in recent decades

Traditional activity	Current market tendencies
*Production of commodities (homogeneous products)	*Differentiated production
*Cash markets with little information or planning	*Increase in contracts and planning
*Growers and marketers involved in many activities	*Specialisation in stages of production and marketing
*Financing and investment as control elements	*Market information as an element of control
*High risk as regards price and production	*Decrease in uncertainty and a growing relationship between the risk of the activity and the safety and quality of the product
*No influence of the producer on price	*Implication of the producer in negotiation and price
*Source markets influenced by local or regional factors	*Growing influence of internationalisation on producer markets
*Independent stages of production, marketing, distribution and consumption	*Agri-food system with interdependent stages
***Competitiveness based on the concentration of production and capital**	***Greater relevance of competitiveness based on technology, efficiency and quality-environmental factors**

Fulton and Sanderson (2002) and Galdeano (2000).

The adaptation of co-operatives (traditional entities of social economy) to the new market conditions is a process common to many countries. As well as being a current characteristic of the European Union, this phenomenon can also be observed in such countries as the United States, Canada, Japan, Australia or New Zealand (Ménard and Klein, 2004). Within this new framework of competitiveness and liberalisation of the market several studies have focussed on changes in management or strategic changes in European co-operatives. Amongst them we could highlight those of Van Bekkum and Van Dijk (1997) on agricultural co-operatives in the European Union, of Parnell (2001) on co-operatives in the United Kingdom, of Galdeano and Rodríguez (2000) based on Andalusian agricultural co-operatives, or of García *et al.* (2002) on agricultural co-operatives in the Canaries.

In the European sector in particular, although the speed of economic developments sometimes exceeds the capacity of co-operatives to react to them, the tendency in recent years is towards their consolidation as providers of the necessary elements of competitiveness to adapt agricultural activity to the agri-food market (Nilsson, *et al.*, 1997). Data of the General Committee for Agricultural Co-operation show the current relevance of these organisations, due above all to the growth experienced over the last three decades (especially, in countries such as Germany, Austria, France, Greece or Spain). They now number some 30,000 co-operatives promoting 50% of agricultural input, and as mentioned previously their participation in other activities in the sector is in the region of 60%. Within this context the activity of co-operatives in the horticultural sector is particularly notable. In countries such as Denmark, Holland or Belgium, 70-80% of the national volume of fruit and vegetables is marketed through co-operatives. In Spain the percentage is 15% for fruit and 40% for vegetables (General Committee for Agricultural Co-operation, 2000).

In general terms horticulture differs from other sectors due to the number and diversity of products it covers and the perishable nature of most of them (implying limited storage possibilities and the need for fast marketing). By extension this also implies that the co-operatives need to adapt faster than in other sectors (Arcas and Ruiz, 2004). In the specific case of the European Union, there tends to be less intervention and a marked decentralisation of market regulation, which corresponds, to a great degree, to these entities, known currently as organisations of producers of fruit and vegetables (OPFV). These co-operatives (OPFV) have also been channelling incentive programmes of the CAP towards developing quality-environmental investment in the horticultural sector.

2.2. Quality-Environmental Practices and Competitiveness in the Agricultural Co-operatives

In sectors such as the fresh fruit and vegetable sector in the European Union, where the added value is relatively little in comparison with processed products and the difference between price at origin and final price is very high, it is understandable that quality and environment-friendly production are put into practice by co-operatives not only due to the existing incentive programmes, but also as they are considered elements of differentiation in the market.

Early research on quality-environment management in agriculture divided the driving forces into compliance-push, and demand-pull categories (Batie and Ervin, 1998). Compliance-push forces generally emanate from the expectation of stronger public environmental program requirements. Demand-pull forces are led by private market/consumer preferences for specific environmental quality attributes. Most recent literature considers a major diversity of specific motivations. For example, the OECD, identifies five drivers: government policies and regulations, commercial and economic considerations, corporate image, codes of conduct, and growing pressures from financial/investment community (OECD, 1998). Carpentier and Ervin (2002) show six types of motivations:

- Improvement of productivity. The creation of integrated production and marketing systems and other tasks necessary to implement a quality-environment management program, such as environmental audits, can lead to cost reductions and/or opportunities for new products (Esty and Porter, 1998, Reinhardt, 2000).

- Differentiating products for demand requirements (for example, green consumers). Although still a small portion of the market, retail products that emphasise environmental objectives are increasing rapidly in many OECD countries.

- Pre-empting or mitigating future environmental regulations. Traditionally, this motivation is widely considered for the industrial sector. Nevertheless, the OECD (1998) noted this same incentive as a major factor in farmers voluntarily forming community-based associations to achieve improved environmental conditions (water pollution problems, high level of insecticides in production, etc.). This category of motivations also includes actions to assure foreign market access that might otherwise be closed by non-tariff trade barriers (for example, the trade in products of agricultural biotechnologies may apply here).

- Strategically managing competitors. Incurring additional costs to improve environmental performance may increase some firms' profits if the actions cause competitors' costs to rise even further than their own (Salop and Scheffamn, 1983).

- Capturing more value in the market. This strategy combines cost reduction, product differentiation, and competitor management to shift market conditions and capture more value along the supply and marketing chains (Reinhardt, 2000).

- Managing risk and uncertainty more effectively. A firm is naturally concerned with the risk of financial harm from environmental incidents. Types of financial harm include the cost of cleanup from an environmental accident, legal liability for environmental damage, foregone profits due to the interruption of business practices following an environmental accident, and losses caused by a damaged reputation in the eyes of government officials, consumers and the public.

Many of these incentives should apply to agricultural co-operatives and farmers. However, traditional limitations exist for their application to farms, in particular, because of their small size and heterogeneous production characteristics and the relative lack of quality and environmental regulation. A few recent empirical studies have referred to quality-environment management in agri-businesses. A review of the empirical evidence by the OECD (2001) concludes that overall there appears to be a positive correlation between environmental and commercial/financial performances. Admundson and Forester (2001) show that companies that invest in business quality-environmental management can do at least as well economically as other companies. Céspedes and Galdeano (2004) show a high correlation between quality-environmental investment and value added in horticultural co-operatives.

The present work focuses in the productivity improvement in marketing co-operatives (thus avoiding the problem of small size or production heterogeneity). Indicators of corporate productivity may constitute a useful tool for the study of the strategic changes considered (the output/input relationship). Recently several works have also focussed on this aspect, although mainly outside the European context: Ferrier and Porter (1991), and Ariyaratne *et al*., (1997) both base their works on agricultural co-operatives in the United States; Kawamura (1997) and Kondo and Yamamoto (2002) study co-operatives from different sectors in Japan; within Europe Vargas and Pelayo (1998) focus on co-operatives from the Spanish food industry and Hughes (1998) analyses agricultural co-operatives from the Czech Republic. Nevertheless, these studies do not consider the impact of quality-environmental factors.

Bearing in mind the lack of this type of work, especially on the horticultural sector, the following sections present a study of total factors productivity and its components (technological and efficiency change) including a measure of quality-environmental change in marketing co-operatives. The methodology adopted is Malmquist indices, and an analysis is also provided of the relationship of the indicators with other variables, which are considered relevant for the competitiveness in this sector.

3. Methodology

3.1. Malmquist Productivity Change Indices

The most elemental approach to study productivity is by calculating the so-called "apparent productivity" of a factor, which is measured as the quotient between an output measure and the quantity of input used to obtain it. Nevertheless, production is usually the result of the application of a group of different factors, and it is therefore more appropriate to calculate an indicator of "total productivity of the factors" which considers all the inputs of the productive process together.

Studies on productivity have become more popular thanks to the application of Malmquist indices, especially after the influential works by Caves *et al.* (1982), which developed the Malmquist productivity index from the notion of "proportional scaling" introduced by Malmquist (1953). Färe *et al.* (1992) combined ideas on measurement of efficiency from Farrell (1957) and on measurement of productivity from Caves *et al.* (1982) to develop a Malmquist index of productivity change. To construct these indices it is necessary to define the distance functions. The input distance function is defined as the maximum reduction of inputs maintaining the output level constant, within the production possibilities set **S**. For a generic firm at period **t**, this is expressed as:

$$D_0^t(x^t, y^t) = (\inf\{\theta : (\theta x^t, y^t) \in S^t\})^{-1} = (\sup\{\theta : (x^t/\theta, y^t) \in S^t\})^{-1} \quad (1)$$

where **x** is the input vector $[x^t = (x^t_1,....., x^t_m) \in R^+_M]$, **y** the output vector $[y^t = (y^t_1,....., y^t_n) \in R^+_N]$, $\boldsymbol{\theta}$ a scalar (equal to the efficiency score) which measures the proportional reduction in inputs while maintaining the output level. To construct the Malmquist indices it is necessary to define the distance functions with respect to two different periods in time (in which productivity changes are measured): one of which is defined by observation and the other by the reference period of the technology. Thus we obtain:

$$D_0^t(x^{t+1}, y^{t+1}) = (\inf\{\theta : (\theta x^{t+1}, y^{t+1}) \in S^t\})^{-1} \quad (2)$$

The distance function D_0^t (x^{t+1}, y^{t+1}) measures the maximum reduction of inputs to make possible (x^{t+1}, y^{t+1}) in technology period t. In a similar way, the distance function of the observation (x^t, y^t) in period t+1 can be defined as:

$$D_0^{t+1}(x^t, y^t) = (\inf\{\theta : (\theta x^t, y^t) \in S^{t+1}\})^{-1} \quad (3)$$

The Malmquist index of total factor productivity (TFP), M_0 $(x^{t+1}, y^{t+1}, x^t, y^t)$ between period t and period t+1 can be defined as follows:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1}) D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t) D_0^{t+1}(x^t, y^t)} \right]^{1/2} \quad (4)$$

which is the composed geometric mean for two Malmquist productivity indices defined by Caves *et al.* (1982): the first evaluated with respect to technology at period t, and the second with respect to technology at period t+1.

From a more traditional perspective, the productivity of factors is considered to be due to technological change. In other words, the productive units are assumed to be located always on their technological frontiers, excluding the possibility of inefficiency in production. However, in the presence of productive inefficiencies an improvement in efficiency may also prove to be a major source for improving productivity without requiring a technical change. Likewise, an improvement in technology does not necessarily have to be accompanied by an increase in productivity if there has not been a simultaneous loss of productive efficiency (Nishimizu and Page, 1982). Accepting that the productive change can be divided into the result of technological progress and the variations in efficiency levels, Färe *et al.* (1992) relate the Malmquist indices of productivity with the measures of efficiency and propose the decomposition of growth in productivity of the same observation into the aforementioned components (technological change and efficiency change). Equation (4) can be decomposed as follows:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \underbrace{\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}}_{\text{efficiency change index}} \times \underbrace{\left[\frac{D_0^t(x^{t+1}, y^{t+1}) D_0^t(x^t, y^t)}{D_0^{t+1}(x^{t+1}, y^{t+1}) D_0^{t+1}(x^t, y^t)} \right]^{1/2}}_{\text{technological change index}} \quad (5)$$

where the first component of the product measures the change in efficiency ("catching up") and the second one captures the shift in the production frontier ("technological change") between period t and period t+1. The Malmquist TFP index is therefore expressed as the product of the efficiency change index (EFC) and the technological change index (TEC): M_0 = EFC_0 x TEC_0. The EFC component measures the changes in productive efficiency and shows how much closer (or farther away) a firm gets to the frontier made up of "best practice" firms. This index is greater than, equal to, or less than unity depending on whether the evaluated firm improves, stagnates, or declines. The technological change component, TEC, measures how much the frontier shifts, and indicates whether the best practice relative to which the evaluated firm compared is improving, stagnating, or deteriorating. Whatever the case, the index will take a value greater than, equal to, or less than unity. The Malmquist TFP index (M) results can be interpreted in a similar fashion.

In order to calculate these indices it is necessary to solve several sets of linear programming problems. We start by considering the analysis of a set of Decision Making Units (DMUs), in this particular case a set of co-operative firms observed (i = 1, ..., L). We assume that there are L DMUs and that each DMU consumes varying amounts of m different inputs to produce n outputs in each period t. The i^{th} DMU, in period t is therefore represented by the vectors (x_i^t, y_i^t). We should consider the following input-oriented linear programming model to measure the distance function of observed DMU_i at period t from the frontier built on the observation at period t+1:

$$\left[D_{0m}^t(x^{t+1}, y^{t+1})\right]^{-1} = \text{Min}\ \theta \quad (6)$$
$$\text{Subject to } \sum_i \lambda_i^t x_{mi}^t \le \theta x_{mi}^{t+1} \ \ \forall m; \ \sum_i \lambda_i^t y_{ni}^t \ge y_{ni}^{t+1} \ \ \forall n; \ \lambda_i^t \ge 0 \ \ \forall i$$

where $\lambda^t = (\lambda_1^t, ..., \lambda_L^t)$ is a vector of weights that forms a convex combination of observed firms relative to which the subject firm's efficiency is evaluated. Using this linear programming model we can compute the different mixed distance functions involved in two periods, t and t+1. Following Färe *et al.* (1994) we will compute four distance functions involved in each pair of time periods: $D_i^{t|t}$, $D_i^{t+1|t+1}$, $D_i^{t+1|t}$ and $D_i^{t|t+1}$.

Another consideration in the present analysis is that we assume constant returns to scale (CRS). This is a common assumption in a decomposition of the Malmquist productivity indices. According to Färe *et al.* (1994), with constant returns to technological scale a reasonable technological reference is obtained for technical change (that representing a shift in the maximum average productivity associated to the most productive scale) even in the presence of variable returns to scale. A further advantage of CRS is that results are coincidental regardless of whether we solve the linear programming models under the input- or output-oriented approaches (Tortosa-Ausina *et al.*, 2003). Additionally, this consideration allows a more direct comparison between our results and other similar studies on co-operatives referenced above.

For efficiency measurement of a given DMU we consider the distance function involved in a generic period t computing $D_i^{t|t}$ ($D_i^{t|t} \leq 1$). With $D_i^{t|t} = 1$ the interpretation is that the i^{th} firm lies on the boundary of the production set of period t and is thus efficient. The other firms with scores below unity will be inefficient. Following Tortosa-Ausina *et al.* (2003) and for the sake of simplicity, when referring to efficiency scores and efficiency measurement, $D_i^{t|t}$ will be labeled θ_i, although it must not be forgotten that all the θ_i correspond to the generic period analysed t.

3.2. Bootstrapping efficiency scores and Malmquist Indices

The linear programming model (6) is built in the context of non-parametric envelopment estimations, of which standard output-oriented DEA (Data Envelopment Analysis) is the most widely used. Among other advantages, this method offers flexibility in the functional form of the technological frontier. Nevertheless, its deterministic nature (by means of radial measurements within the sample) does not allow the statistical contrast of hypotheses on the results obtained. In order to solve this problem, Simar (1992) and Simar and Wilson (1998) use the "bootstrap" procedure in productivity analysis based on the bootstrap techniques developed originally by Efron (1979), whose main objective is to approximate the unknown population distribution function. Interested readers can see the works by Simar and Wilson (1998, 1999) for a more complete description of the algorithm, since here we provide only a brief description.

In the efficiency framework, Simar and Wilson (1998) have proposed a bootstrap procedure consisting of the generation of B samples as $Z = \{(x^*_i, y^*_i)\}^L_{i=1}$ by mimicking the Data Generating Process. For each firm and for each of these B samples, the bootstrap value of efficiency can be estimated as:

$$\theta^*(x_i, y_i) = \min\{\theta \mid \sum_i \lambda_i x_i^* \leq \theta x_i \quad y_i \leq \sum_i \lambda_i y_i^* \quad \forall \lambda_i \geq 0\} \tag{7}$$

Thus we obtain the empirical distribution of each firm as $\{\theta^*_b(x_i, y_i)\}^B_{b=1}$ and its sample mean $B^{-1} \sum^B_{b=1} \theta^*_b(x_i, y_i)$ could be used as an estimator of efficiency. This allows us to obtain of the "bias" in efficiency estimation as *bias* = $B^{-1} \sum^B_{b=1} \theta^*_b(x_i, y_i) - \theta(x_i, y_i)$, and $\theta'(x_i, y_i) = \theta(x_i, y_i) -$ *bias* provides us with the corrected estimator.

Simar and Wilson (1998, 1999) have adapted the bootstrap procedure to the Malmquist indices. In this case the algorithm generates bootstrap efficiencies preserving the temporal correlation of the data by exchanging the distribution function for a bivariate kernel estimator of density. The main change is the re-sampling procedure: we resample in pairs of efficiency values for two consecutive time periods instead of re-sampling in the single efficiency values. The empirical distribution of each index for each firm can be expressed as $[M^*_b(t, t+1)^i, EFC^*_b(t, t+1)^i, TEC^*_b(t, t+1)^i]^B_{b=1}$. In a similar way as described above for efficiency estimators, we can obtain the bias for each index. Additionally, this procedure allows us to make a test of significance for each index calculated (Tortosa-Ausina *et al.*, 2003).

Although this method can be used for statistical inference of productivity indices among sample firms, in this work (as a first productivity analysis on the co-operative sector under study) the bootstrap procedure is used to give statistical consistency to our second step of analysis (Tortosa-Ausina *et al.*, 2003), i.e. to determine the relationship between the results and other variables of competitiveness in the co-operative sevctor as a whole.

3.3. Quality-Environment Incorporated Malmquist Indices

The Malmquist index formalism can be extended to take into account quality-environment attributes of inputs and outputs in addition to ordinary input and outputs. We extend the standard input-output model by introducing an attribute vector **a**, whose components are to be associated with non-marketable goods.

In our analysis the quality-environment factor in horticultural co-operatives is measured by the quantity of fruit and vegetables produced by farmers, which are rejected as they do not meet the minimum standards required by the different quality-environment certificates employed by these organisations. Therefore, following Yaisawarng and Klein (1994), who apply a measure of quality in electricity industry, we include the undesirable output attributes as ordinary intput in co-operatives. In input-oriented Malmquist indices, this can be interpreted as meaning that a firm can reduce the undesirable output attributes and cost (as an ordinary) input while maintaining a given level of ordinary outputs. Additionally, as pointed out by Hailu and Veeman (2001), the input-oriented approach is consistent with the input substitution issue. A reduction in undesirable outputs requires the diversion of other ordinary inputs from the production of desirable outputs, i.e. it requires the use of additional inputs or the sacrifice of ordinary outputs (Hailu and Veeman, 2001).

The input distance function in equation (1) can be extended to incorporate the quality-environment factor **a** [considering the production possibilities set **S**: $S^t = \{(x^t, a^t, y^t)$: x^t *and* a^t *can produce* $y^t\}$] for a generic firm in a reference period **t**, as in equation (8):

$$D'^{t}_{0}(x^t, a^t, y^t) = (\inf\{\theta : (\theta x^t, \theta a^t, y^t) \in S^t\})^{-1} \tag{8}$$

where a modified input-oriented efficiency measure, $\boldsymbol{\theta a}$, is included (Chen, 2001; Giannakis *et al.*, 2003). The quality-environment incorporated Malmquist index is then calculated from equation (4), which is essentially the Malmquist index extended with the quality-environment attribute **a**.

$$M_0^a = \left[\frac{D'^{t}_{0}(x^{t+1}, a^{t+1}, y^{t+1})D'^{t+1}_{0}(x^{t+1}, a^{t+1}, y^{t+1})}{D'^{t}_{0}(x^t, a^t y^t)D'^{t+1}_{0}(x^t, a^t, y^t)}\right]^{1/2} \tag{9}$$

Following Färe *et al.* (1995) and Giannakis *et al.* (2003), we define a quality-environment change index QEC as specified in the equation (10).

$$QEC_0 = \left[\frac{D'^{t}_{0}(x^t, a^{t+1}, y^t)D'^{t+1}_{0}(x^{t+1}, a^{t+1}, y^{t+1}}{D'^{t}_{0}(x^t, a^t y^t)D'^{t+1}_{0}(x^{t+1}, a^t, y^{t+1})}\right]^{1/2} \tag{10}$$

A comparison of equations (9) and (10) reveals that QEC isolates the effects of quality-environment change by making single period input and output evaluations under mixed period quality-environment attributes. If we assume that D' is multiplicatively separable in quality attributes and inputs-outputs, the quality-environment change index can be expressed as a separate component of the quality-environment incorporated Malmquist index [i.e. $D'^t_0 (x^t, a^t, y^t) = d^t_0 (a^t) \times D^t_0 (x^t, y^t)$]. Then it is possible to express the decomposition of the Malmquist index as follows:

$$M_0^a = QEC_0 \times M_0 \tag{11}$$

where M_0 is considered a quality-environment independent Malmquist index (Giannakis *et al.*, 2003). Additionally, similar to decomposition made in equation (5), the quality-environment incorporated Malmquist index M_0^a can be decomposed into separate quality-environment, technological and efficiency change indices as follows:

$$M_0^a = QEC_0 \times M_0 \times TEC_0 \quad (12)$$

To the extent that the Malmquist index calculated using equation (11) is similar to that of the Malmquist index from equation (9), the quality-environment factor may be interpreted as consistent with the assumption of multiplicative separation. Significant differences in the results from the two approaches may be interpreted as indication that simple quality-environment independent productivity indices do not reflect the true or holistic measure of productivity (Färe *et al*., 1995; Giannakis *et al*., 2003) and hence may be an unreliable basis for **x** factor calculations. The bootstrap procedure can be also applied in a similar way as described in the last subsection for the calculation of these new indices.

4. Data and Specification of Variables

4.1. Characteristic of the Co-operative Sample

The relevance of the fruit and vegetable sector in final agricultural production in both Spain and the EU (about 50% and 40% respectively) and current demand are contributing to greater attention to the role of co-operatives in this sector's competitiveness and also to their quality management.

Marketing horticultural co-operatives (OPFV) in Andalusia (where the horticultural production represents 24% of the national total) are the reference for this study. These entities carry out the handling and/or transformation, as well as the subsequent marketing of the fruit and vegetables produced by their grower members. They are especially important in finding answers to current demand requirements in the food sector, bearing in mind the small family-scale nature of many of the farm enterprises. Additionally, they are proving to be key elements in quality improvement and the development of environment-friendly practices in the horticultural sector (motivated in part by community subsidies). Since the 1990s in the Andalusian horticultural co-operatives have been applied different CAP incentive programmes for the improvement of quality management. European Commission (EC) Regulation 2078/92 and in a wider sense EC Regulation 2200/96 are particularly noteworthy. The latter have represented a considerable intensification of the quality-environment investment.

Quality-environment management in horticultural co-operatives has been aimed primarily at promoting more ecological production: the application of integrated pest management, investment in irrigation systems to foment saving and avoid pollution; the application of methods which avoid soil pollution; the use of reusable packaging; more frequent analysis of soil, water, plants and waste. Ad of this has meant a major investment in technical assistance and quality controls. In many cases these measures are included in quality certifications recently applied to fresh vegetables, such as the EUREP-GAP (Good Agricultural Practices) code or others which specialise more in the horticultural sector, such as the UNE-155 or the Integrated Production developed by the regional government.

This analysis has been based on the annual financial reports and surveys of 51 marketing co-operatives, over the period 1994-2001. This sample represents 58% of the total volume of production of the Andalusian horticultural co-operatives, taking the average figures of the period under study. They are characterised by the intensive production system of the farmer members and the existence of common markets and clients (Galdeano, 2000). The period under study is deemed of interest for several reasons, most of which have been outlined in the second section. Over the last decade there has been an acceleration of the process of concentration of European food distribution, and consequently an increase in direct sales to distribution chains. The co-operatives have therefore had to make a greater effort in terms of planning, volume, quality and other added values. Also, the reform of the fruit and vegetable Common Market Organisation in 1996 has meant that these entities have had to adapt their organisation providing incentives for technological renovation and investment in product quality. In addition, the increasing liberalisation and internationalisation of the markets has supposed an increase in the competitive scenario for Andalusian co-operatives, strongly oriented towards exports (Galdeano and Rodríguez, 2000). This fact is conditioning corporate management strategies (return on investments, capitalisation, risk management, solvency, etc.).

4.2. Specification of Variables

The productive activity of horticultural marketing co-operatives has been characterised by the consideration of an output, value added, and three inputs: two traditional productive factors, labour and capital, and a quality-environment attribute.

Output or average production has been obtained from the accountable value added (value of sales minus purchases - i.e. the value of farmers' production-). Although, the output is usually measured by sales or by the production volume, in this case the value added is used because the main activities in the marketing co-operatives are: handing, packaging, transporting, coordination of associated farmers' supply, quality management, technical assistance, etc. Therefore, we consider the analysis of productivity related to these activities.

The labour factor has been obtained from labour expenses, and the capital factor from the depreciation expenditures (economic redemption of fixed assets). The quality-environment attribute is measured by the non-marketable produce of farmer members, which does not reach the minimum standards required by the various quality-environment certificates. As indicated above, this input represents an undesirable output that does not reduce the ordinary output, because the purchases of produce in the accountable value added do not include this withdrawal of goods. The quality-environment variable ("Quality-Env.") is measured in thousands of kilograms. The monetary variables (value added, labour and capital) have been corrected for inflation and are expressed in real terms (converted to thousands of euros). The descriptive statistics of said variables are shown in table A.1 of the Appendix.

5. Analyses and Results

5.1. Results of Malmquist Indices

According to the methodology considered the Malmquist productivity indices are calculated with respect to a technology characterised by the existence of constant returns to scale. Taking into account the considerations made in Subsection 3.3, we estimate three models: a quality-environment independent Malmquist index, "M-independent"(M_0), as specified in equation (5); a quality-environment index, "M-quality-environment" (QEC_0), as specified in equation (10); a Malmquist index with quality-environment incorporated, "M-total" (M_0^a), as specified in equation (9).

Table 2 shows the average of bootstrapped efficiency scores obtained under these hypotheses for each of the years under study (we only show the corrected estimator of efficiency, θ', omitting the original efficiency score and its bias). Following Simar and Wilson (1998) we have averaged the corresponding bootstrap values over time to obtain estimates of significance for the period and also to reflect the evolution in the co-operative sector as a whole.

Table 2. Annual average of bootstrapped efficiency scores.

Year	M-independent	M-quality-environment	M-total
1994	0.786	0.705	0.892
1995	0.824	0.698	0.911
1996	0.815	0.762	0.910
1997	0.849	0.849	0.927
1998	0.871	0.886	0.940
1999	0.855	0.877	0.934
2000	0.878	0.889	0.946
2001	0.892	0.908	0.962
Total period	0.846	0.822	0.928

The results show the performance of efficiency throughout the period under study for the three models considered. This performance is most relevant in quality-environment model (a difference of 20% between the first and last years). The total model obtains higher efficiency scores, indicating a better explanatory power by including all input. Thus, the incorporation of the quality-environment factor is important for the conclusions of the productivity analysis.

The total model shows an average efficiency score over the whole period of 0.928 in the co-operatives sample. This indicates that there remains a margin for improvement of approximately 7% in the use of production factors to achieve the maximum level of efficiency in obtaining the output. Nevertheless, an upward trend in efficiency over the period is observed (a difference of 7% between the first and last years).

In order to assess productivity change over time, we calculate the Malmquist indices of change in total factor productivity (TFP index). This is decomposed in efficiency change (EFC) and technological change (TEC). In order to also take into account quality-environment changes (QEC), the TFP index for M-total is decomposed based on equations (9) and (10) (i.e. distance functions multiplicatively non-separable in quality-environment attributes and input-outputs) and equation (12) (i.e. distance functions that may be multiplicatively separable). Table 3 presents the results, showing annual averages of the corresponding bootstrap values over time to obtain estimates of significance for the period and for the whole sample.

Table 3. Average of bootstrapped Malmquist indices for the period 1994-2001.

Years	M-total (non-separable)				M-total (separable)			
	TFP	EFC	TEC	QEC	TFP	EFC	TEC	QEC
1994/1995	1.010*	1.021**	1.014**	0.976**	1.040**	1.027**	1.016**	0.976*
1995/1996	0.980**	0.998	0.994*	0.988*	0.980**	0.995*	0.997	0.988*
1996/1997	1.040**	1.019**	1.005*	1.016**	1.044**	1.026**	1.002	1.016**
1997/1998	1.027**	1.014**	0.991*	1.022**	1.035**	1.019**	0.994*	1.022**
1998/1999	1.017**	0.993*	1.004*	1.020**	1.025**	0.998	1.007*	1.020**
1999/2000	1.048**	1.013**	1.007*	1.028**	1.059***	1.023**	1.008*	1.028**
2000/2001	1.056***	1.017**	1.006*	1.033**	1.053***	1.026**	1.004*	1.033**
Average of period	1.026**	1.011**	1.003*	1.012**	1.032**	1.016**	1.004*	1.012**

Note: significant differences from unity are reported: *** Significant at 1%; ** significant at 5%; * significant at 10%

The data obtained indicate an average annual increase in total productivity of the factors of 2.6% over the period studied using M-total non-separable, and 3.2% using M-total separable model. In both models, the change in efficiency and in quality-environment can be seen to have a greater effect than technological change. Also, we can see that most of the calculated bootstrap indices are statistically significant.

The results of the model with multiplicatively separable quality-environment factors and input-outputs show similar, albeit stronger results than the M-total non-separable. However, the calculated Malmquist productivity changes from the two versions are different, suggesting that the data are not consistent with separability (Färe *et al.*, 1995). A two-sample t-test (assuming unequal variance) of the average Malmquist indices for the co-operatives for the whole period also rejected the null-hypothesis (at 90% confidence) that the indices from the two approaches have similar means (Table 4).

Table 4. The t-test two sample (assuming unequal variances) of average Malmquist productivity indices.

	M-total non-separable	M-total separable
Mean	1.026	1.032
Variance	0.01421	0.02904
Hypothesised mean difference	0	
t-statistic	-1.552	
t critical value ($\alpha = 0.1$)	1.440	

Based on this contrast we do not pursue the results from the separable version further. Nevertheless, these results can be interpreted as supporting a non-separable total quality-environment incorporated approach rather than partial approaches (Giannakis *et al*., 2003).

Figure 1 shows the results of M-total non-separable indices. It can be seen how EFC and QEC have the greatest impact on the change in TFP, especially since 96/97.

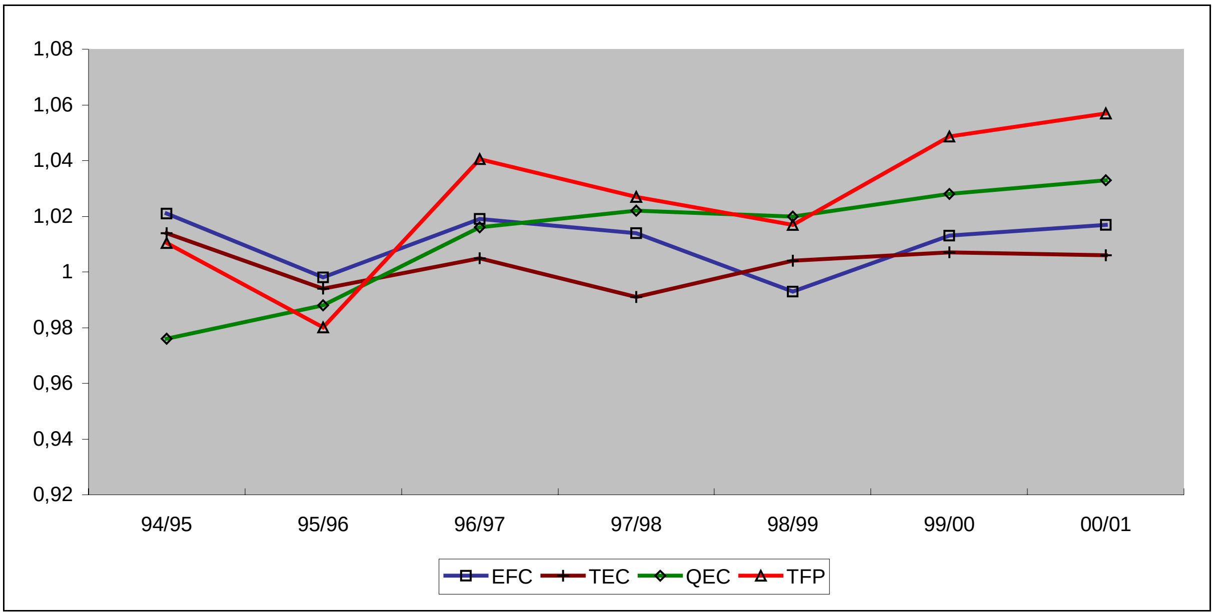

Figure 1. Results of the Malmquist indices for the period 1994-2001.

The low ratio obtained for TEC may be due to homogeneity over the period in the renovation of assets and in the incorporation of technology, for which there have traditionally been major incentives in co-operatives in this sector (EC Regulation 1035/72, Regional Economic Incentives, etc.). The intensification of investment in quality-environment factors in the period may explain the evolution of QEC and the impact on TFP. The changes in efficiency may be due to different factors such as the appearance of returns to scale, better qualification of the labour factor or improvement in quality management of co-operatives (Céspedes and Galdeano, 2004). The following Subsection presents an analysis of several determinants of productivity.

5.2. Analysis of the Determinants of Productivity Change

In order to examine the incidence of some economic characteristics of co-operatives, and based on the accuracy of most of the bootstrapped indices obtained, we estimate a fixed effects model using our panel of data (obtaining the average effects for the whole sample). The linear fixed effects model is given by $Y_i^{\,t} = \alpha + \beta X_i^{\,t} + \gamma^{\,t} + \varepsilon_i^{\,t}$, where $Y_i^{\,t}$ is the dependent variable, α is the intercept, $X_i^{\,t}$ is the vector of the explanatory variables, $\gamma^{\,t}$ is a vector of dummy variables to reflect time effects, and $\varepsilon_i^{\,t}$ is a random disturbance term. As dependent variables we consider the change in TFP, the EFC, TEC and QEC. To complete the vector of explanatory variables (in addition to capital and labour), we consider a firm size variable (total assets), a quality-environment variable (annual investment in quality-environment improvement –due to its high correlation detected with the QE attribute input, the latter is omitted from the estimation-) and a variable of productivity (profit before interest and tax/ labour costs). Bearing in mind the relevance of the quality-environment factor we consider additionally a *spillover* variable (which is frequently related to R&D) as another input of the knowledge production of a firm). In this case, the quality-environment investment in other firms of the Andalusian horticultural sector is used to measure a proxy of spillover related to the quality-environment variable (considering the other production techniques and management leads to more severe competition –Blomstrom and Kokko, 1998-). The explanatory variables are expressed in first differences given the nature of our dependant variables. We also introduce six temporary variables ($\gamma^{95/96}$... $\gamma^{00/01}$) for the temporary effects (excluding the temporary variable correspondent to 94/95). Since heteroscedascity is present, the method of generalised least squares (GLS) is used. The results are presented in Table 5.

Table 5. Correlates of the productivity growth in the co-operatives (1994-2001).

	EFC	TEC	QEC	TFP change
Intercept	0.822 (3.48)***	0.641 (1.63)*	0.902 (3.61)***	0.834 (3.52)***
Size	0.135 (1.24)	0.228 (1.87)**	0.168 (1.64)*	0.184 (1.90)**
Q-E investment	0.321 (2.18)**	0.219 (1.85)**	0.419 (2.19)**	0.380 (2.85)***
Labour productivity	0.340 (2.75)***	0.264 (2.03)**	0.366 (2.72)***	0.335 (2.12)**
Spillover (Q-E)	0.155 (1.61)*	0.079 (0.98)	0.245 (2.09)**	0.138 (1.31)
Capital	0.287 (2.15)**	0.324 (2.73)***	0.287 (2.15)**	0.328 (2.92)***
Labour	-0.232 (1.98)**	-0.242 (1.93)**	-0.225 (1.93)**	-0.229 (1.95)**
$\gamma^{95/96}$	-0.188 (1.86)**	-0.204 (1.98)**	0.210 (1.94)**	-0.264 (2.19)**
$\gamma^{96/97}$	0.174 (1.75)*	0.158 (1.62)*	0.405 (1.73)*	0.283 (2.60)***
$\gamma^{97/98}$	0.224 (1.92)**	-0.163 (1.66)*	0.328 (2.19)**	0.218 (1.90)**
$\gamma^{98/99}$	-0.205 (1.89)**	-0.234 (1.97)**	0.290 (2.15)**	-0.210 (1.94)**
$\gamma^{99/00}$	0.311 (2.70)***	0.160 (1.62)*	0.278 (2.02)**	0.368 (2.85)***
$\gamma^{00/01}$	0.305 (2.24)**	0.155 (1.61)*	0.351 (2.94)***	0.391 (3.08)***
N	357	357	357	357
R^2	0.315	0.172	0.283	0.310

Note: t-tests are reported in parentheses. *** Significant at 1%; ** significant at 5%; * significant at 10%

The values obtained show that there is significant correlation between productivity growth and Q-E investment. The correlation of this investment with TEC may be due to new production techniques and technological innovation (R&D expenditures) in horticultural co-operatives are related to the quality-environment factors in recent years (Céspedes and Galdeano, 2004). The spillover variable has a positive effect on productivity measures, but the parameters are only significant for the QEC and EFC. Correlation between the size of the co-operative and efficiency is positive but not significant. This may be due to the characteristics of the horticultural sector analysed, since the grower-members tend to run relatively small family-owned businesses. Other studies by Kondo *et al.* (1997) or Kondo and Yamamoto (2002), on Japanese agricultural co-operatives, also show that there is no relationship between size and management efficiency; in the case of agricultural co-operatives in the United States, however, works by the likes of Ariyarathe *et al.* (1997) indicate that there is a significant relationship between both variables, although the productive activity is carried out on large farms. Therefore, management efficiency (planning, capacity to adapt, information transfer, etc.) may be greater for a small or medium-sized co-operative. The labour productivity shows significant parameters, especially for efficiency, quality-environment and TFP change; this may be related in turn to the adoption of more stringent quality-environment control and the subsequent need to employ more qualified staff. In general, the R^2 of the estimations, with relatively parsimonious explanatory variables, are statistically significant (Novales, 1996).

6. Conclusions

The new concept of agricultural activity, marked recently by the process of large-scale demand concentration by the distribution chains, as well as commercial liberalisation on a European and global level, have made it quite clear that co-operative marketing entities play, or can play, a major role in the agri-food system. These new market conditions produce new challenges and impose changes in the strategic approach of these co-operatives: differentiated marketing and a greater degree of specialisation; an increase in planning and direct contracting with the centres of distribution (vertical integration); the provision of more information to their grower members and the connection with the other agents in the agri-food chain; the reduction of risk as regards price and the development of quality-based strategies; an increase in competitiveness based on technology, efficiency and quality-environment factors.

The present study has focussed in particular on the analysis of changes in the productivity of marketing co-operatives, taking the Andalusian horticultural sector as reference, and considering the possible impact of the quality-environment variable. The inclusion of this factor lead to performance explanation of results of productivity Malmquist indices. Additionally, the analysis made supports a non-separable total quality-environment incorporated approach rather than partial approaches.

The co-operatives analysed show an efficiency level of 0.928, which indicates that there still exists a margin for improvement of approximately 7% in the use of production factors to achieve the maximum level of efficiency in obtaining the output. Nevertheless, a considerable increase can be seen in the efficiency of the co-operatives over the whole period, reflected in the evolution of productivity. It is observed that efficiency and quality-environment change have a greater impact on the TFP change, especially since 96/97. This result is particularly motivated by the intensification of quality-environment investment in horticultural co-operatives following the growing demand for added values. This fact is corroborated by the high correlation between the quality-environment variable and productivity measures. This may also be related to the effect of labour productivity and the necessary better-qualified staff in the co-operatives

References

Admundson, P. and Foerster, S. R. (2001). Socially responsible investing: Better for your soul or your bottom line? Canadian Investment Review 14 (4) Winter. http://www.investmentreview.com/archives/winter01/social.html

Andalusian Council of Agriculture and Fisheries (Several years). Annual reports, from 1993 to 2002. Sevilla, Spain.

Arcas, N. and Ruiz, S. (2004). Marketing and performance of fruit and vegetable co-operatives. Journal of Co-operative Studies (in press).

Ariyaratne,C. B., Featherstone, A. M., Lagemeier, M. R. and Barton, D. G. (1997). An analysis of efficiency of Midwestern agricultural co-operatives. In The Western Agricultural Economics Association, selected paper of the 1997 Annual Meeting. Reno/Sparks, Nevada, USA, 13-16 July, 1997: 1-13.

Batie, S. and Ervin, D. (1998). Will business-led environmental initiatives grow in agriculture? Choices (Fourth Quarter): 4-10.

Bekkum, O. F. van, Dijk, G. van (eds) (1997). Agricultural Co-operatives in the EU. Assen.

Blomstrom, M. and Kokko, A. (1998). Multinational corporations and spillovers. Journal of Economic Surveys 12: 247-277.

Carpentier, C. L. and Ervin, D. E. (2002). Business aproaches to agri-environmental management: incentives, constraints and policy issues. Paris: OECD.

Caswell, J. A. and Modjuska, E. M. (1996). Using informational labelling to influence the market for quality in food products. American Journal of Agricultural Economics 78: 1248-1253.

Caves, D. W., Christensen, L. R. and Diewert, W. E. (1982). The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica 50(6): 1393-1414.

Céspedes, J. and Galdeano, E. (2004). Environmental practices and the value added of horticultural firms. Business Strategy and the Environment Journal 13(3): 403-414.

Chen, S. (2001). Productivity changes of hospitals in Taiwan: A quality-incorporated Malmquist index bootstrap approach. National Science Council, Republic of China.

Efron, B. (1979). Bootstrap methods: Another look at the Jacknife. Annals of Statistics 7: 1-20.

Estruch, V. (1994). La calidad y las explotaciones agrarias. Investigaciones Agrarias 9(3): 345-358.

Esty, D. and Porter, M. (1998). Industrial ecology and competitiveness: strategic implications for the firm. Journal of Industrial Ecology 2(1): 35-43.

Färe, R., Grosskopf, S., Lindgren, B. and Roos, P. (1992). Productivity change in Swedish pharmacies 1980-1989: A non-parametric Malmquist approach. Journal of Productivity Analysis 3: 85-101.

Färe, R., Grosskopf, S., Norris and M., Zang, Z. (1994). Productivity growth, technical progress, and efficiency change in industrialized countries. American Economic Review 84: 66-83.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society, Ser.A 120: 253-281.

Ferrier, G. D. and Porter, P. K. (1991). The productive efficiency of US milk processing co-operatives. Journal of Agricultural Economics 42: 161-173.
Fulton, M. and Sanderson, K. (2002). Co-operatives and farmers in the new agriculture. Report prepared for the Co-operatives Secretariat Agriculture and Agri-Food Canada, Centre for the Study of Co-operatives, Unversity of Saskatchewan.
Galdeano, E. (2000). Estudio de competitividad de las entidades asociativas andaluzas de comercialización hortofrutícola. Universidad de Almería y Consejería de Empleo y Desarrollo Tecnológico. Almería, Spain.
Galdeano, E. and Rodríguez, M. (2000). Cambios de estrategia en las entidades asociativas de comercialización hortofrutícola. Revista de Estudios Agrosociales y Pesqueros 186: 75-103.
García, A. M., Oreja, J. R. and González, E. (2000). Las relaciones verticales y el poder de negociación de agricultores integrados en forma cooperativa frente a los individuales. Revista CIRIEC-España 41: 111-138.
General Committee for Agricultural Co-operation (GCAC) (1999). The European model of agriculture: the way ahead, Pr(99)88F1. Bruxelles: GCAC.
General Committee for Agricultural Co-operation (2000). The agricultural co-operation in the European Union: tendencies and current issues. Bruxelles: GCAC.
Giannakis, D., Jamasb, T. and Pollit, M. (2003). Benchmarking and incentive regulation of quality service: an application to the UK electricity distribution utilities. Cambridge Working Papers in Economics CWPE 0408. University of Cambridge. Masschusetts Institute of Technology Center for Energy and Environmental Policy Research.
Hakelius, O. (1999). How will European farmer co-operatives cope with the challenges of today and tomorrow? LTA 4/99: 491-499. Bruxelles: GCAC.
Hailu, A. and Veeman, T. S. (2001). Non-parametric productivity analysis with undesirable outputs: an application to the Canadian pulp and paper industry. American J. of Agricultural Economics 83(3): 605-616.
Hughes, G. (1998). Agricultural productivity and farm structure in the Czech Republic. Working Paper No. 2/7, University of London, Wye College, London.
Kawamura, T. (2000). 'What caused and downs of Japanese agricultural co-operatives?: a TFP analysis. In IAMA Food and Agribusiness Forum, Chicago, 25 June, 2000: 1-11.
Kondo, K., Demura, K. and Yamamoto, Y. (1997). The technical efficiency of agricultural co-operatives Hokkaido's dairy-farming region. Review of Agricultural Economic 53: 55-59.
Kondo, K. and Yamamoto, Y. (2002). Technical change and technical efficiency of agricultural co-operatives in Japan: a nonparametric Malmquist approach. In Second North American Productivity Workshop. Union College, Schenectady, USA, 20-22 June, 2002: 1-20.
Malmquist, S. (1953). Index numbers and indifference surfaces. Trabajos de Estadística 4: 209-242.
Ménard, C. and Klein, P. G. (2004). Organisational issues in the agri-food sector: toward a comparative approach. American Journal of Agricultural Economics (forthcoming).
Nilsson, J., Kyriakopoulus, K. and Dijk, G. van (1997). Agricultural co-operatives in the European Union: current challenges and trends. In Rural Co-operatives in the Perspective of the Integration with the European Unio*n*, Zakopane, Poland, December, 1997: 1-21.
Nishimizu, M. and Page, J. M. (1982). Total factor productivity growth, technological progress and technical efficiency change: dimensions of productivity changes in Yugoslavia 1965-78. Economic Journal 92: 920-936
Novales, A. (1996). Econometría (3rd ed.). New York: McGraw-Hill.
OECD (1998). Co-operative approaches to sustainable agriculture, p 107. Paris.
OECD (2001). Encouraging environmental management in industry, p 52. Paris.
Parnell, E. (2001). Supporting rural co-operation: the role of the Plunkett Foundation. Journal of Co-operative Studies 34(1): 3-12.
Reinhardt, F. (2000). Down to earth: applying business principles to environmental management. Boston: Harward Business School Press.
Salop, S. C. and Sheffman, D. T. (1983). Raising rivals' costs. American Economic Review 73: 267-271.
Simar, L. (1992). Estimating efficiencies from frontier models with panel data: a comparison of parametric non-parametric semi-parametric methods with bootstrapping. Journal of Productivity Analysis 3: 167-203.

Simar, L. and Wilson, P. W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in non-parametric frontier models. Management Science 44(1): 49-61.
Simar, L. and Wilson, P. W. (1999). Estimating and bootstrapping Malmquist indices. European Journal of Operational Research 115: 459-471.
Tortosa-Ausina, E., Grifell-Tatje, E., Armero, C. and Conesa, D. (2003). Malmquist productivity indices: An application to Sapnish savings banks. Working Paper 2003/02, Centre of Applied Economic Research, University of New South Wales.
Vargas, A. and Pelayo, Y. (1998). Los grupos cooperativos en la industria de la alimentación en España. In VIII Congreso Hispano-Francés AEDEM. Benalmádena. 2-5 June, 1998: 1309-1317
Yaisawarng, S. and Klein, J. D. (1994). The effects of sulfur dioxide controls on productivity change in the US electric power industry. Review of Economics and Statistics LXXVI(3): 447-460.

Appendix

Table A.1. Descriptive statistics of the sample (annual averages)

Year	Variable	Average	Standard deviation	Maximum	Minimum
1994	Value added	473.36	297.56	1,123.05	126.51
	Capital	217.79	145.04	641.13	59.48
	Labour	703.74	426.48	1,114.18	162.21
	Quality-Env.	420.25	182.13	985.62	109.17
1995	Value added	508.04	389.22	1,205.12	98.74
	Capital	234.75	147.73	665.10	105.56
	Labour	809.28	462.63	1,650.34	228.62
	Quality-Env.	379.91	163.46	978.19	93.51
1996	Value added	494.15	252.90	1,098.83	147.25
	Capital	228.17	173.74	765.26	55.93
	Labour	834.02	469.14	1,708.12	155.88
	Quality-Env.	400.09	202.03	1,006.24	115.32
1997	Value added	515.26	362.45	1,131.04	129.93
	Capital	325.83	179.70	863.08	105.56
	Labour	879.42	510.36	1,804.21	219.16
	Quality-Env.	380.21	190.08	970.16	98.39
1998	Value added	529.32	348.25	1,127.67	135.42
	Capital	342.07	202.51	915.06	110.43
	Labour	906.82	558.30	1,798.19	245.33
	Quality-Env.	357.93	156.18	889.72	103.05
1999	Value added	520.48	368.11	1,122.40	158.12
	Capital	331.44	175.92	864.92	107.10
	Labour	884.26	543.78	1,738.03	225.41
	Quality-Env.	304.15	109.66	851.28	87.90
2000	Value added	525.96	318.29	1,190.35	163.57
	Capital	316.83	152.12	792.28	97.44
	Labour	810.19	492.33	1,681.27	228.34
	Quality-Env.	293.89	121.16	860.04	92.18
2001	Value added	534.06	342.18	1,201.64	163.29
	Capital	319.41	164.23	814.33	98.82
	Labour	823.17	508.35	1,648.01	203.24
	Quality-Env.	268.36	114.06	902.50	88.41