# Productivity and efficiency analysis of horticultural co-operatives

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## Abstract

Development of the horticultural sector in the Mediterranean agricultural areas of Spain is closely linked to the activity of co-operative organisations for the production and marketing of produce. These entities are especially important in finding answers to current demand requirements in the food market, bearing in mind the small family-scale nature of many of the farm enterprises in this sector. The present paper explores the ability of horticultural co-operatives in adapting to the new challenges in this sector from a productivity analysis viewpoint. Total factor productivity and efficiency are considered indicative measurements of the response of these organisations to the current market environment. In this study, Malmquist productivity indices are estimated using non-parametric techniques and taking as reference panel data of Andalusian horticultural co-operatives for the period 1995-2004. For a more in-depth analysis, productivity indices are broken down into technological change and efficiency change indicators, also considering the impact of other variables of co-operatives. The indicators obtained showed a relevant increase in efficiency for the period under study and a positive relationship between the results and quality investment. On the whole this research work adds to studies in the adaptation process of co-operatives in the current competitive scenario, offering insight into the improvement in total productivity and its correlation with several management variables in the fruit and vegetables sector.

**Additional key words**: horticultural sector, Malmquist indices, quality.

## Resumen

### Análisis de productividad y eficiencia de las cooperativas hortofrutícolas

El desarrollo del sector hortofrutícola en las regiones mediterráneas españolas está estrechamente ligado a la actividad de producción y comercialización a través de las organizaciones cooperativas. Estas entidades son especialmente importantes para dar respuesta a los actuales requerimientos de la demanda agroalimentaria, teniendo en cuenta que la producción de este sector se basa en explotaciones familiares de pequeña escala. En el presente trabajo analizamos la capacidad de las cooperativas hortofrutícolas para adaptarse a las nuevas condiciones del mercado, desde la perspectiva de la productividad. Se considera que la productividad total de los factores y la eficiencia constituyen medidas indicativas de la respuesta de estas organizaciones al nuevo contexto del mercado. En este análisis se aplica el método de los índices de productividad de Malmquist, estimándose mediante técnicas no paramétricas y tomando como referencia un panel de datos de cooperativas hortofrutícolas andaluzas para el período 1995-2004. Para un estudio en mayor profundidad, los índices de productividad se descomponen en indicadores de cambio tecnológico y cambio de eficiencia, analizando también su relación con otras variables características de las cooperativas. Los indicadores obtenidos muestran un elevado incremento en la eficiencia a lo largo del período de estudio y una correlación positiva de los resultados con la inversión en calidad. En general, esta investigación amplía los estudios relativos al proceso de adaptación de las cooperativas en el actual escenario competitivo, ofreciendo evidencias sobre la mejora en la productividad total y su correlación con determinadas variables de gestión en el sector de las frutas y hortalizas.

**Palabras clave adicionales:** calidad, índices de Malmquist, sector hortofrutícola.

# Introduction

The new conditions in the agri-food market represent new challenges for agricultural systems and are imposing changes in their strategic organisation. Growing demand requirements, the concentration of distribution chains and world-wide commercial liberalisation give greater relevance to certain business sectors in the agricultural systems and food market. In this context, marketing co-operatives are particularly prominent: they tend to sell directly to distribution centres, and have an important co-ordinating role of farming activity (Perrot *et al.*, 2001).

In the European Union (EU), co-operative entities are responsible for over 60% of the harvest, handling and marketing of agricultural products, with a turnover of approximately 210,000 million euros (GCAC, 2000).

With such a high profile in the European agricultural model, expectations for attaining sustainable and competitive agriculture rely to a great extent on the cooperative sector's ability to adapt to the new market conditions (GCAC, 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.

These factors are bringing about a change in both the organisation and functioning of agricultural systems by marketing co-operatives. 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 innovation, investment in technology, quality improvement or productivity (Perrot *et al.*, 2001; Hendrikse and Bijman, 2002).

Recent years have also seen a number of studies related to the adaptation process of the agricultural co-operatives (Hakelius, 1999; Fulton and Sanderson, 2002; Ménard and Klein, 2004). Analyses of productivity and its essential components (technological change and efficiency) constitute a useful tool to describe this process and have been applied by several authors (Ferrier and Porter, 1991; Ariyaratne *et al.*, 1997; Damas and Romero, 1997; Hughes, 1998; Vidal *et al.*, 2000; Kawamura, 2000; Montegut *et al.*, 2002; Kondo and Yamamoto, 2002, amongst others) to assess the suitability of co-operatives in this increasingly competitive scenario.

This work aims to analyse both efficiency and change in total productivity in the marketing co-operatives,

taking the horticultural sector as a reference and using non-parametric output-oriented Malmquist indices of productivity (Färe *et al.*, 1992, 1994). The productivity changes in co-operatives are considered an important indicator of the adaptation of the horticultural system to current market conditions.

# Current challenges facing agricultural co-operatives. An overview

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 agricultural co-operatives are immersed (Hendrikse and Bijman, 2002).

The increasingly competitive environment implies the need to adapt the corporate organisation of co-operatives. In order to maintain their market position and sustain profitability, they must invest in innovation, quality and human resources. Table 1 shows some of the current tendencies in the agri-food system.

**Table 1.** Changes in the agri-food system 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. |
| — Farmers and marketers involved in many activities. | — Specialisation in stages of farming and marketing. |
| — Financing and investment as control factors. | — Market information as a factor of control. |
| — High risk as regards price and production. | — Decrease in uncertainty and a growing relationship between the risk of the activity and the healthiness and quality of the product. |
| — No influence of the farmer on price. | — Implication of the farmer in negotiation and price. |
| — Farming systems influenced by local or regional factors. | — Growing influence of internationalisation on farming systems. |
| — Independent stages of farming, 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 technological intensification and production efficiency. |

*Source:* Fulton and Sanderson (2002) and Galdeano (2000).

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 farmer members and connection with the other agents in the agri-food chain.

— Reduction of risk as regards price and the development of strategies based on quality.

— Increase in competitiveness based on technological innovation and economic efficiency.

The process of adaptation of agricultural co-operatives to the new market conditions is common to many countries. As well as being a current characteristic of the EU, this phenomenon can also be observed in countries such as the United States, Canada, Japan, Australia or New Zealand (Ménard and Klein, 2004).

In European agriculture in particular, although the speed of economic developments sometimes exceeds the ability of co-operatives to react to them, there is a tendency in recent years towards their consolidation as providers of the necessary elements of competitiveness to adapt farming activity to the agri-food market (Nilsson *et al.*, 1997).

Data of the General Committee for Agricultural Co-operation (GCAC) show the current relevance of these organisations, mainly due 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 around 60% in the region.

Within this context, the activity of farming co-operatives in the horticultural sector is especially relevant. 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 (GCAC, 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 farming co-operatives need to adapt faster than in other sectors (Arcas and Ruiz, 2003). In the specific case of the EU, there tends to be less intervention and a marked decentralisation of market regulation, which corresponds, to a great degree, to these entities.

Indicators of corporate productivity and efficiency constitute a useful tool for the study of strategic changes. The co-ordination effort and management of associated farmers' production are essentially motivated by productivity gains (Hernández-Espallardo and Arcas-Lario, 2003). Bearing in mind the co-operatives' relevant role in the Spanish agricultural system, several research works have focused on the analysis of their productivity and especially their efficiency component. From an economic and accountable perspective, this efficiency is related to economic and financial profitability (Caballer and Segura, 1995; Segura and Oltra, 1995; Vidal, 1999; Galdeano and Rodríguez, 2000; Server and Melián, 2001). Other analyses have focused on the outputs/inputs functional relationship by estimating the efficiency frontier using non-parametric methods (Millán, 1997, for the rural credit co-operatives; Damas and Romero, 1997, for olive co-operatives in Jaén; Vidal *et al.*, 2000, for horticultural co-operatives in the region of Valencia) and parametric methods (Marco and Moya, 1999, for credit co-operatives; Montegut *et al.*, 2002, and Sabaté, 2002, for fruit co-operatives in Lleida)[1]. Also, several of these studies analyse the relation of efficiency indicators with several variables such as size, integration and purchases of produce from farmer members (Segura and Vidal, 2001; Montegut *et al.*, 2002; Sabaté, 2002).

In the international context, several research works have focused on this issue: Ferrier and Porter (1991), and Ariyaratne *et al.* (1997) both base their works on agricultural co-operatives in the United States; Sueyoshi *et al.* (1998), Kawamura (2000), and Kondo and Yamamoto (2002) study farming co-operatives in Japan; Hughes (1998) analyses farming co-operatives from the Czech Republic.

In the present work, an analysis of productivity change and its components in marketing co-operatives is undertaken in order to extend studies on these entities and characterise recent tendencies in co-opera-

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[1] These methods are also applied in studies on farming production, e.g. Colom (1994), for parametric methods, Gonzalez *et al.* (1996) and Reig-Martínez and Picazo-Tadeo (2004), for non-parametric methods.

tivism in the horticultural sector. The methodology adopted is Malmquist indices considering that they offer the analysis of total factors productivity, combining efficiency measures and traditional measurement of productivity —based on technological change— (Färe *et al.*, 1992). Estimations of the distance functions are done by non-parametric mathematical programming techniques[2], and an analysis is also provided of the relationship between productivity indicators and other management variables.

## Methodology: Malmquist productivity indices

The most elemental approach to study productivity is by calculating the so-called «apparent or partial 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 applying a group of different factors, and is therefore more appropriate to calculate an indicator of «total factor productivity» (TFP) 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 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 the measurement of efficiency from Farrell (1957) and on the measurement of productivity from Caves *et al.* (1982) to develop a Malmquist index of productivity change. To construct these indices the distance functions must be defined. The output 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:

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

where $x$ is the input vector, $y$ the output vector, $\theta$ a scalar (equal to efficiency scores) 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 increases are measured): one of which is defined by observation and the other by the reference period of the technology. Thus, the following is obtained :

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

The distance function $D_0^t (x^{t+1}, y^{t+1})$ measures the maximum reduction of inputs 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:

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

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 technological 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). Thus, accepting that the productive change can be divided into the result of technological progress and the variations in efficiency levels, Färe *et al.* (1994) 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). Thus, the Malmquist index of TFP, $M_0 (x^{t+1}, y^{t+1}, x^t, y^t)$ between period $t$ and $t+1$ is expressed as follows:

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

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[2]  This approach is selected as it has no predetermined functional relation between inputs and outputs. Although the advantages or disadvantages of parametric and non-parametric methods have been widely discussed (e.g. Lovell, 1993; González *et al.*, 1996), the consensus is that neither technique is better than the other, because of the trade-off they are affected by (Tortosa-Ausina *et al.*, 2003). Parametric techniques have the advantage of allowing for random error and for formal statistical testing of hypotheses; in contrast they impose a particular functional form that presupposes the shape of the frontier. On the other hand, non-parametric techniques tend to envelop data more closely, but they do not allow for random error. Nevertheless, the resulting flexibility in the production function is an advantage whenever the true functional relationship between inputs and outputs is unknown (Lovell, 1993).

This may be rewritten as follows:

$$M_0\,(x^{t+1},\,y^{t+1},\,x^t,\,y^t)= \frac{D_0^{t+1}\,(x^{t+1},\,y^{t+1})}{D_0^t\,(x^t,\,y^t)} \times$$

$$\times \left[\frac{D_0^t\,(x^{t+1},\,y^{t+1})\,D_0^t\,(x^t,\,y^t)}{D_0^{t+1}\,(x^{t+1},\,y^{t+1})\,D_0^{t+1}\,(x^t,\,y^t)}\right]^{1/2} \qquad [5]$$

where the first component of the product measures the change in efficiency (or relative position with respect to the technological frontier) between two periods (*t* and *t*+1). The geometrical average of the two ratios in brackets shows the shift of the technological frontier or the technological change between *t* and *t*+1. The Malmquist TFP index is therefore expressed as the product of the efficiency change index (EFC) and the technological change index (TEC):

$$\text{EFC} = \frac{D_0^{t+1}\,(x^{t+1},\,y^{t+1})}{D_0^t\,(x^t,\,y^t)} \qquad [6]$$

$$\text{TEC} = \left[\frac{D_0^t\,(x^{t+1},\,y^{t+1})\,D_0^t\,(x^t,\,y^t)}{D_0^{t+1}\,(x^{t+1},\,y^{t+1})\,D_0^{t+1}\,(x^t,\,y^t)}\right]^{1/2} \qquad [7]$$

Expression [6] measures the changes in productive efficiency and may have a value greater than, equal to or less than the unit, depending on whether efficiency improves, stagnates, or declines between period *t* and period *t*+1. In other words, a value greater than the unit indicates that the distance in inputs of an observation in *t* with respect to its contemporary frontier is greater than that same distance in *t*+1, having therefore achieved an approximation to the technological frontier or an improvement in efficiency. Expression [7], on the other hand, measures the effect on productivity of technological change, and it may also have a value greater than, equal to or less than the unit, depending on whether technology improves, stagnates, or declines between period *t* and period *t*+1. In a similar fashion, the Malmquist TFP index will take values greater than the unit, equal to it or less than it, depending on whether total productivity increases, remains stable or falls between *t* and *t*+1.

Data consist of a known vector of inputs and outputs of *L* firms (in this case a set of co-operatives) at both period *t* and *t*+1:

$$Z = \{(x_i^t,\,y_i^t,\,x_i^{t+1},\,y_i^{t+1}),\,i = 1,\,\dots,\,L\} \qquad [8]$$

where $x_i^t = (x_{i1}^t,\dots,\,x_{in}^t,\dots,\,x_{iN}^t)' \in \mathfrak{R}_+^N$ and $y_i^t = (y_{i1}^t,\dots,\,y_{im}^t,\dots,\,y_{iM}^t)' \in \mathfrak{R}_+^M$ are the input and output vectors corresponding to firm *i*, *i* = 1, ..., *L* in period *t* respectively.

For both period *t* and *t*+1, the production set, and consequently all distances defined from it are unknown. Following Färe *et al.* (1992) the four distances, which make up eq. [5], can be estimated via linear programming techniques. For this, the following linear programming model is considered for firm *i*, *i* = 1, ..., *L*:

$$[D_i^t\,(x_i^t,\,y_i^t)]^{-1} = \max \theta \qquad [9]$$

subject to

$$\theta\,y_{im}^t \leq \sum_{j=1}^L \lambda_j^t\,y_{mj}^t, \qquad m = 1,\,\dots,\,M,$$
$$\sum_{j=1}^L \lambda_j^t\,x_{jn}^t, \leq x_{in}^t, \qquad n = 1,\,\dots,\,N,$$
$$\lambda_i^t \geq 0, \qquad\qquad\quad i = 1,\,\dots,\,L.$$

where $\lambda^t = (\lambda_1^t,\dots,\,\lambda_L^t)$ is a vector of weights that forms a convex combination of observed firms relative to which the subject firm's efficiency is evaluated. Linear programming model [9] calculates the distances $D_i^t\,(x_i^t,\,y_i^t)$. Computing $D_i^{t+1}\,(x_i^{t+1},\,y_i^{t+1})$ is exactly like [9], where *t*+1 is substituted for *t*.

Two further linear programming models are needed to estimate the mixed-period cases [2] and [3]. The first of these is computed for each *i* firm as:

$$[D_i^t\,(x_i^{t+1},\,y_i^{t+1})]^{-1} = \max \theta \qquad [10]$$

subject to

$$\theta\,y_{im}^{t+1} \leq \sum_{j=1}^L \lambda_j^t\,y_{mj}^t, \qquad m = 1,\,\dots,\,M,$$
$$\sum_{j=1}^L \lambda_j^t\,x_{jn}^t, \leq x_{in}^{t+1}, \qquad n = 1,\,\dots,\,N,$$
$$\lambda_i^t \geq 0, \qquad\qquad\quad i = 1,\,\dots,\,L.$$

As Färe *et al.* (1994) state, observations involved in [10] are from both period *t* and *t*+1. The reference technology relative to which $(x_i^{t+1},\,y_i^{t+1})$ is evaluated is constructed from observations in *t*. To compute the second mixed-period distance function, $D_i^{t+1}\,(x_i^t,\,y_i^t)$, the *t* and *t*+1 superscripts in [10] must simply be reversed. Following Färe *et al.* (1994) four distance functions involved in each pair of time periods are computed:

$$D_i^{t/t},\ D_i^{t+1/t+1},\ D_i^{t+1/t}\ \text{and}\ D_i^{t/t+1}.$$

Another consideration in the present analysis is that constant returns to scale (CRS) are assumed. 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[3]. A further advantage of CRS is that results are coincidental regardless of whether the linear programming models are solved under the output- or input-oriented approaches (Tortosa-Ausina *et al.*, 2003). Additionally, this consideration allows a more direct comparison between the present results and other similar studies on farming co-operatives referenced above.

For efficiency measurement of a given firm the distance function involved in a generic period *t* is considered 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 $\theta_i$, although it must not be forgotten that all the $\theta_i$ correspond to the generic period analysed *t*.

## Data and variables

Horticultural marketing co-operatives in Spain 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 farmer members. They are proving to be key elements in quality improvement and farming management in the horticultural sector.

This analysis uses a balanced panel data based on the financial reports and surveys of 51 co-operatives located in Andalusia (South of Spain)[4], over the period 1995-2004. This sample represents 18-20% of the total volume of production of the Spanish 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. 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 marketing co-operatives have therefore had to make a greater effort in terms of planning, volume, quality and other added values. In addition, the increasing liberalisation and internationalisation of the markets has supposed an increase in the competitive scenario for horticultural co-operatives, strongly oriented towards exports (Galdeano and Rodríguez, 2000).

The productive activity of horticultural co-operatives has been characterised by the consideration of an output, value added, and two productive factors, labour and capital. Output or average production has been obtained from the accountable value added (value of sales minus purchases)[5]. The labor factor has been obtained from labour expenses (Fuentes *et al.*, 2001; Kondo and Yamamoto, 2002), and the capital factor from the depreciation expenditures (accountable replacement value of fixed assets)[6]. All variables have been corrected for inflation (base year 1995) and are expressed in real terms (converted to thousands of euros). The descriptive statistics of said variables are shown in Table 2.

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[3] The assumption of constant returns to scale (CRS) to estimate Malmquist indices is widely discussed. As pointed out by Grifell-Tatjé and Lovell (1995), a Malmquist index may not be a correct measure of TFP changes when variable returns to scale (VRS) are assumed for the technology. Ray and Desly (1997) contend that there may be confusion in the simultaneous use of CRS and VRS technologies within the same decomposition of the Malmquist index. Coelli and Rao (2003) state that it is important that CRS be imposed upon any technology that is used to estimate distance functions for the calculation of a Malmquist TFP index applicable to both firm-level and aggregate data; otherwise the resulting measures may not properly reflect the TFP gains or losses resulting from scale economies. In order to avoid this controversy, the CRS assumption is maintained.

[4] The horticultural sector in this region has been characterised by considerable growth in recent decades. Nevertheless, especially since the middle 1990's, the crop area cultivated and the number of associated farmers in co-operatives has become more stable. Additionally their common location leads to homogeneity of products and production systems. Co-operatives play a quite relevant role in this sector, accounting for 70% of marketable production (Céspedes and Galdeano, 2004).

[5] Output is usually measured by turnover or production volume. In this case value added is used because the main activities in the farming co-operatives are handing, packaging, quality control, technical assistance, etc., the analysis of productivity is therefore considered in relation to these activities.

[6] This includes the depreciation of buildings, equipment and machinery. Although, a correct measure of the capital factor is obtained from the permanent inventory, sufficient information is not available to construct this. Nevertheless, Martínez *et al.* (1999), among others, consider replacement value as an approximation to this measurement. It is also taken into account that in the period of study fiscal facilities did not exist for the co-operatives of this sector.

**Table 2.** Descriptive statistics of the sample. Mean annual data (thousands of euros)

| Year | Variable | Average | Standard deviation | Maximum | Minimum |
|---|---|---|---|---|---|
| 1995 | Value added | 473.36 | 297.56 | 1,123.05 | 126.51 |
| | Capital | 217.79 | 145.04 | 641.13 | 59.48 |
| | Labour | 203.74 | 126.48 | 516.17 | 82.23 |
| 1996 | Value added | 508.04 | 389.22 | 1,205.12 | 98.74 |
| | Capital | 234.75 | 147.73 | 665.10 | 105.56 |
| | Labour | 229.28 | 121.45 | 475.27 | 73.68 |
| 1997 | Value added | 494.15 | 252.90 | 1,098.83 | 147.25 |
| | Capital | 228.17 | 173.74 | 765.26 | 55.93 |
| | Labour | 174.09 | 84.28 | 408.12 | 91.26 |
| 1998 | Value added | 515.26 | 362.45 | 1,131.04 | 129.93 |
| | Capital | 325.83 | 179.70 | 863.08 | 105.56 |
| | Labour | 189.96 | 100.31 | 394.62 | 97.41 |
| 1999 | Value added | 529.32 | 348.25 | 1,127.67 | 135.42 |
| | Capital | 342.07 | 202.51 | 915.06 | 110.43 |
| | Labour | 203.24 | 123.19 | 401.04 | 136.28 |
| 2000 | Value added | 520.48 | 368.11 | 1,122.40 | 158.12 |
| | Capital | 331.44 | 175.92 | 864.92 | 107.10 |
| | Labour | 238.15 | 118.33 | 419.06 | 147.53 |
| 2001 | Value added | 525.96 | 318.29 | 1,190.35 | 163.57 |
| | Capital | 316.83 | 152.12 | 792.28 | 97.44 |
| | Labour | 210.13 | 102.33 | 399.24 | 137.16 |
| 2002 | Value added | 534.06 | 342.18 | 1,201.64 | 163.29 |
| | Capital | 319.41 | 164.23 | 814.33 | 98.82 |
| | Labour | 194.35 | 99.27 | 386.43 | 132.21 |
| 2003 | Value added | 520.42 | 303.07 | 1,143.31 | 167.24 |
| | Capital | 302.06 | 149.25 | 798.85 | 111.13 |
| | Labour | 214.38 | 110.15 | 403.19 | 108.32 |
| 2004 | Value added | 561.10 | 305.21 | 1,217.06 | 204.62 |
| | Capital | 330.69 | 138.47 | 714.43 | 99.17 |
| | Labour | 202.53 | 97.82 | 382.09 | 103.91 |

## Results

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. Table 3 shows the average efficiency scores obtained for each of the years under study.

Over the period under study co-operatives show an average level of efficiency of 0.931, which 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.

Six co-operatives from the sample were totally efficient over the whole period, and only three showed values below 0.80 in most of the years analysed. In general terms, the co-operatives show an increase in efficiency over the whole period (a difference of 7.5% between the first and last years).

The Malmquist indices of change in total factor productivity (TFP index), change in efficiency (EFC) and technological change (TEC) are shown in Table 4.

The data obtained indicate an average annual increase in total productivity of the factors of 1.3% over the period studied (i.e. an increase of 9.6% over the whole period). Within this increase, the change in efficiency can be seen to have had a greater effect than technological change (with average annual increases of 0.9% and 0.4%, respectively).

In Figure 1, representing these indices, it can be seen that the evolution of the change in TFP is quite similar

**Table 3.** Efficiency scores (annual averages)

| Year | Average | Standard deviation | Maximum | Minimum |
|------|---------|--------------------|---------|---------|
| 1995 | 0.892 | 0.087 | 1.000 | 0.685 |
| 1996 | 0.911 | 0.074 | 1.000 | 0.710 |
| 1997 | 0.908 | 0.078 | 1.000 | 0.689 |
| 1998 | 0.926 | 0.069 | 1.000 | 0.747 |
| 1999 | 0.940 | 0.055 | 1.000 | 0.783 |
| 2000 | 0.931 | 0.058 | 1.000 | 0.780 |
| 2001 | 0.944 | 0.055 | 1.000 | 0.788 |
| 2002 | 0.960 | 0.051 | 1.000 | 0.802 |
| 2003 | 0.955 | 0.062 | 1.000 | 0.793 |
| 2004 | 0.967 | 0.053 | 1.000 | 0.776 |
| Total period | 0.931 | 0.066 | 1.000 | 0.748 |

to that of EFC, showing the greater impact of the latter on total productivity.

The changes in efficiency may be due to different factors such as the appearance of scale effects, improvement of quality (both in the product and in management), more skilled labour, etc. In order to examine the incidence of some of these factors, the correlation of annual efficiency levels in the co-operatives in the sample (see the average data in Table 3) will now be analysed with a size variable (value of total assets), with a quality variable (annual expenditures in quality management systems) and with a variable of labour qualification measured by the share of qualified staff (number of engineers, technicians and managers over total workers)[7]. Table 5 shows the Pearson correlation coefficients between the above-mentioned variables and efficiency.

The values obtained show that there is no significant correlation (though there is a positive one) between the size of the co-operative and efficiency in this case. This may be due to the characteristics of the horticultural sector analysed, since the grower-members tend to run relatively small family-owned businesses (see Discussion). The quality factor, on the other hand, shows a positive correlation with efficiency, significant at 5%, for every year except 1995. This result is thought to be motivated by the intensification of investment in quality in the horticultural sector following the growing demand for added values. A positive relationship can also be observed between the higher level of labour qualification and efficiency. The correlation coefficients are particularly significant in the final years of the study.

## Discussion

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-operatives play, or can play, a major role in the agri-food system. The strategies of co-operatives based on quality, technological innovation

**Table 4.** Malmquist indices for the period 1995-2004

| Years | Efficiency change (EFC) | Technological change (TEC) | Change in total factor productivity (TFP) |
|-------|-------------------------|-----------------------------|-------------------------------------------|
| 1995/1996 | 1.021 | 1.014 | 1.035 |
| 1996/1997 | 0.997 | 0.994 | 0.991 |
| 1997/1998 | 1.019 | 1.005 | 1.024 |
| 1998/1999 | 1.015 | 0.991 | 1.006 |
| 1999/2000 | 0.990 | 1.004 | 0.993 |
| 2000/2001 | 1.014 | 1.007 | 1.020 |
| 2001/2002 | 1.017 | 1.006 | 1.024 |
| 2002/2003 | 0.995 | 1.009 | 1.004 |
| 2003/2004 | 1.013 | 1.005 | 1.018 |
| Average for the whole period | 1.009 | 1.004 | 1.013 |

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[7] The choice of variables affecting efficiency always presents a certain degree or arbitrariness (Irz and Thirtle, 2004). In this case, recent studies on this horticultural sector are followed (e.g. Céspedes and Galdeano, 2004) and the consideration that these variables may not be strictly conventional inputs/outputs (Reinhard *et al.*, 2002).
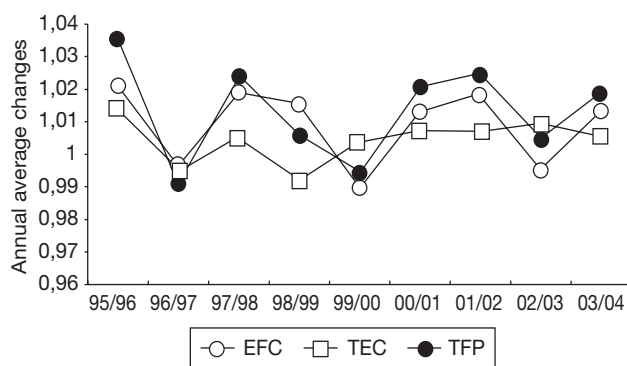
**Figure 1.** Results of the Malmquist indices (EFC: efficiency change, TEC: technological change, TFP: total factor productivity change) for the period 1995-2004.

**Table 5.** Correlation coefficients between levels of efficiency and other economic variables of the co-operatives (1995-2004)

| Year | Size | Quality | Labour qualification |
|---|---|---|---|
| 1995 | 0.1287 | 0.2876 | 0.1752 |
| 1996 | 0.0892 | 0.3564* | 0.2432 |
| 1997 | 0.0928 | 0.3686* | 0.3767* |
| 1998 | 0.1315 | 0.4183** | 0.3018 |
| 1999 | 0.1623 | 0.5045** | 0.3621* |
| 2000 | 0.1407 | 0.4975** | 0.4103** |
| 2001 | 0.2035 | 0.3724* | 0.3701* |
| 2002 | 0.3804* | 0.4769** | 0.3728* |
| 2003 | 0.1765 | 0.3751* | 0.4099** |
| 2004 | 0.2141 | 0.4923** | 0.4168** |

Statistical significance: ** $P < 0.01$. * $P < 0.05$

or efficiency are of particular interest in the current environment.

The present study has focussed on the analysis of changes in the productivity of co-operatives, taking the Andalusian horticultural sector as reference, and considering its two fundamental components: technological change and efficiency.

The co-operatives analysed show an efficiency level of 0.931, 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 periods, reflected in the evolution of productivity. In this sense, the data obtained indicate an average annual increase in TFP of 1.3% (which represents a growth of 9.6% over the whole period). Within this growth a greater effect of change in efficiency can be appreciated.

Additionally, the influence of certain economic variables (size, quality and labour qualification) on the efficiency levels obtained is determined. The results indicate that there is a positive, but not significant correlation between the size of the co-operative and efficiency in this case. 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 Vidal *et al.* (1999) and Montegut *et al.* (2002) on Spanish horticultural co-operatives also show that there is no relationship between size and management efficiency. Likewise works by Kondo *et al.* (1997) or Kondo and Yamamoto (2002) on Japanese agricultural co-operatives (characterised for small scale productive of the members) also obtain low correlation between the two variables[8]. This suggests that management efficiency (planning, capacity to adapt, information transfer, etc.) may be greater for a small or medium-sized co-operative[9].

The quality factor shows a positive correlation with efficiency, significant at 5%, throughout almost all the period. This result is without doubt due to the intensification of investment in quality in the Andalusian horticultural sector since the mid-1990s, especially following the application of Council Regulation 2200/96 (OJ, 1996). Indeed, several certifications of product quality or business management have been adopted by most of the farming co-operatives (Galdeano, 2000)[10].

There is also a positive and significant relationship between the higher level of labour qualification and efficiency in the last years of the study. This may be related in turn to the adoption of more stringent quality

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[8] In the case of agricultural co-operatives in the United States, however, works by the likes of Ariyaratne *et al.* (1997) indicate that there is a significant relationship between both variables (size and efficiency), although the productive activity is carried out on large farms.

[9] Sabaté (2002) also shows that there is no relationship between integration (by second-level agricultural co-operatives) and improvement in management efficiency.

[10] The development of the Community regulation and demand requirements have meant that during the period under analysis quality controls were established in most of the horticultural co-operatives such as the Hazards and Points of Critical Control System, ISO 9002 certification, the Integrated Production System or UNE norm 155001.

control and it indicates a trend towards employing better qualified staff in the co-operatives (Céspedes and Galdeano, 2004) in order to manage associated farmers' activity.

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