Are The Spanish Citrus Farms Efficient?

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Abstract

Spain occupies the first position in the European and Mediterranean rankings of citrus production and trade. In our analysis we assess the technical efficiency with which this sector is operating. The main objective of this study is to analyze productivity and technical efficiency of Spanish citrus sector through citrus farms with high orange production. A stochastic frontier production model is estimated in which the technical inefficiency effects are defined by the time-varying inefficiency model. A primal approach is used to decompose Total Factor Productivity (TFP) growth into its various components. Results indicate improvement in efficiency scores of Spanish citrus farms along the period studied. Allocative efficiencies, technical efficiency change, and scale effects are found to be the main factors that increase TFP growth.

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Introduction

The world citrus production has experienced continuous growth in the last decades. The annual average citrus production was estimated at 105 million tons in 2000-2004 periods (FAO. 2005). Oranges constitute the bulk of citrus fruit production, with more than half of global citrus production in 2004. The citrus production growth is mainly due to the increase of cultivated area and the change in consumer preferences towards more healthy and convenience food consumption.

Citrus fruits are produced all around the world. According to FAO data, in 2004, 140 countries produced citrus fruits. However, most production was concentrated in certain areas. Main citrus fruit producing countries was Brazil, the Mediterranean countries, the United States and China. In the Mediterranean countries, Spain is the leading producing country with more than 5.9 million tons, which represent a 57% of EU production and 6% of the worldwide production. Oranges are the most citrus fruits produced in Spain, representing a 48% of EU production and 5% of the worldwide production (MAPA, 2004).

Moreover, citrus fruits are the first fruit crop in international trade in terms of value with more than 10 millions tons in 2004 (FAO, 2005). The EU is the main destination as well as the main supply region with almost half of the world imports and more than 40% of world exports. The EU is an active trader in the world market. The Mediterranean region plays a prominent role as world fresh citrus exporter, providing nearly 60% of global fresh citrus fruits exports. Spain is the most exporter country with almost 25% of total exportation in the world (FAO. 2005). Moreover, Spain is the leading country worldwide, with a citrus market share of 40.5%, in 2003.

Given the relevance of this sector, the main purpose of this study is to analyze the technical efficiency and to decompose productivity growth into its different components for a sample of Spanish citrus farms from 1995 to 2003. The main motivation of efficiency and productivity studies are the need to investigate and understand the forces that drive agricultural production growth in order to analyse and formulate any desired agricultural policy reform. Whether the future prospects of any potential agricultural policy are concerned with a sustainable or a more intensive agricultural production, the study of individual farm efficiency is essential in order to maximise the anticipated benefits of such a policy. Consequently, efficiency measures can have important implications for issues related to economic survival, the size distribution of farms, the technological adoption and innovations and the overall input use in the agricultural sector. In the developed countries, this can greatly benefit from inefficiency studies which show that it is still possible to raise productivity by improving efficiency, a usually neglected source of productivity improvement, without increasing the resource base or developing new technologies. Gains in agricultural output through the improvement of efficiency levels are becoming particularly important nowadays since the opportunities to increase farm production by bringing additional virgin land into cultivation or by increasing the utilisation of the physical resources have recently been significantly diminishing. In addition, if large inefficiencies exist among the farmers, elimination of them can be proved more cost effective than introducing new technologies as a means of increasing agricultural output and thereby, household income. Furthermore, for individual farms, gains in efficiency are of great substance in periods of financial stress since efficient farms are more likely to generate higher incomes and thus, stand a better chance of surviving and prospering.

The outline of the paper is as follows. After this introduction, in section 2, we mention the applied methodology, the efficiency and productivity concepts, and we introduce the stochastic frontier function and the primal approach used in the decomposition of productivity. Section 3 deal with the description of the data and the empirical model. In section 4, we present the econometric estimation and results. In the last section, we discuss the conclusions.

2. Methodology

Both concepts, productivity and efficiency, have been used in the literature in similar terms, assuming that productivity and efficiency increases are the result of a good performance by the firm. Probably, this fact has generated that both concepts have been used indistinctly (Álvarez, 2001). However, both concepts refer to different aspects of production and not always it is good for the firm to increase productivity or efficiency. When the output or input levels are fixed, then both concepts are identical but when input and output change, the productivity is affected for the scale effect derived from the decreasing returns to scale assumption.

We can differentiate three kinds of efficiency, the technical efficiency are manifested when the firm obtains the maximum level of output from the chosen input combination. We speak about scale efficiency, when the firm is producing with an optimum scale, allowing it to maximise profits. And at last, allocative efficiency is measured when the firm combines inputs to minimize production costs. If firms do not maximise profits (they are not efficient) different combinations of inefficiencies could arise.

The concept of factor productivity has been used quite often in the empirical literature as a synonymous of efficiency. Factor productivity is defined as the ratio between the output level and the quantity of a specific input used to get it. This assimilation makes sense only in the case of a fixed coefficients technology in which the possibilities of substitution among inputs are not considered. The concept of Total Factor Productivity (TFP) has been widely used in the literature. It is defined by the following expression:

$$TFP = \frac{\sum a_i y_i}{\sum b_j x_j} \qquad (1)$$

That is, it is a ratio between a weighted sum of outputs obtained (y_i) and a weighted sum of inputs used (x_j) being a_i and b_j the corresponding output and input weights, respectively. If the firm only generates a single output and we used input prices as weights, we get:

$$TFP = \frac{y}{\sum w_j x_j} = \frac{y}{TC} = \frac{1}{AC} \qquad (2)$$

Where: w_j are input prices, TC is the Total Production Cost and AC is the Average Cost. In this case, TFP and economic efficiency are equivalent concepts. Obviously, we can define alternative measures of TFP depending on the weights used.

Stochastic frontier model

Measurement of efficiency is based on the idea of comparing the actual firm performance with that obtained in a hypothetical situation of profits maximisation. However, this is not possible as the researcher has a lack of information about the sector or some technological restrictions that could exist within the firm. Then, what is usually done is to compare the firm's performance with that of other similar firms belonging to the same sector or industry. This is, precisely, the original idea of the seminal paper by Farrell (1957). His main contribution was to empirically provide a standard reference with which compares the firms' efficiency: the frontier. Thus, efficiency measures are defined in relative terms, that is, in relation with the best firms in the sector, which define such a frontier. His method also allowed distinguishing between technical efficiency and allocative efficiency, which is his second main contribution. These two measures can be combined to provide a measure of total economic efficiency.

A commonly used technique to measure a firm's technical efficiency is the stochastic frontier methodology. First introduced by Aigner, Lovell and Schmidt (1977), and Meeusen and van den Broeck (1977), sought to address the shortcomings of the deterministic approach. Namely, distinguish between exogenous shocks outside the firm's control and inefficiency.

Considerable research applied the basic frontier model such as Forsund, Lovell and Schmidt (1980), Bauer (1990), Battese (1992), Ley (1990) and Beck (1991).

A stochastic frontier production function can be expressed as follows:

$$y_{it} = f(x_{it}, t; \beta) e^{v_{it} - u_{it}} \qquad (3)$$

where y_{it} is the output of the i-th firm ($i = 1,...,N$) in period $t = 1,...,T$, $f(x_{it}, t; \beta)$ represents the production technology, x_{it} is a $(1 \times K)$ vector of inputs and other factors influencing production associated with the i-th firm in period t, β is a $(K \times 1)$ vector of unknown parameters to be estimated.

The disturbance term is composed of two parts: v_{it} a symmetric component permits random variations of the frontier across firms and captures the effects of statistical noise outside the firm's control, is assumed to be iid $\mathrm{N}(0, \sigma_v^2)$, and u_{it} a onesided, non positive, component that captures randomness under the firm's control, i.e., that are associated with output-oriented technical inefficiencies. It is further assumed that the two error terms are independently distributed from each other. The temporal pattern of u_{it} as the changes in technical efficiency over time rather than the degree of technical efficiency *per se* matters. Following Battese and Coelli (1992) specification, we adopt the temporal pattern of technical inefficiency, *i.e.*,

$$u_{it} = \left\{ \exp\left[-\xi \left(t - T \right) \right] \right\} \, u_i \tag{4}$$

Where ξ captures the temporal variation of individual output-oriented technical efficiency ratings, and $t \in \left[1,\ 2,\ ...,\ \mathrm{T}\right]$. If the parameter ξ is positive (negative), technical efficiency tends to improve (deteriorate) over time. If $\xi = 0$, output-oriented technical efficiency is time-invariant. The u_i are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid as truncations at zero of the N(μ, σ_u^2) distribution.

Productivity decomposition

After estimating the model, we measure total factor productivity change and determine its various components. Historically, analyses of TFP change has been calculated using index number techniques to construct a Paasche, Laspeyres, Theil-Törnqvist or Fisher productivity indices with the last two being exact and superlative. All the above indices require either price or quantity data as well as assumptions concerning the structure of the underlying technology and the behavioral objectives of producers. Alternatively TFP growth can be calculated using primal approach following Kumbhakar and Lovell (2000). By using Divisia index, output growth can be decomposed into an input growth and a productivity growth component.

This approach do not require price information or technological neither behavioral assumptions, but they do require the estimation of the production technology. Moreover, Kumbhakar and Lovell (2000) mention that in the case were the price information are available we could include the allocative efficiency component into the primal aproach descomposition.

By using a primal approach, Kumbhakar has attributed output growth to four components: returns to scale, technical change, change in technical efficiency, and allocative inefficiency. Total Factor Productivity (TFP) growth is expressed as follows:

$$\overset{\circ}{TFP} = T\Delta + (\varepsilon - 1)\sum_k (\frac{\varepsilon_k}{\varepsilon})\overset{\circ}{x}_k + \sum_k \left[(\frac{\varepsilon_k}{\varepsilon}) - S_k \right] \overset{\circ}{x}_k + TE\Delta \quad (5)$$

Where a dot over a variable indicates its rate of change. $\overset{\circ}{TFP}$ represents total factor productivity change.

Where $T\Delta = \frac{\partial f(x_{it}, t; \beta)}{\partial t}$, is a measure of the rate of technical change which captures trends in productivity change.

$(\varepsilon - 1)\sum_k (\frac{\varepsilon_K}{\varepsilon})\overset{\circ}{x}_k$ measures the contribution of scale economies to total factor productivity growth. Where $\varepsilon_k = \varepsilon_k(x_{it}, t; \beta) = \frac{x_k \left(\partial f(x_{it}, t; \beta) / \partial x_k \right)}{f(x_{it}, t; \beta)}$ represents the output elasticity with respect to input x_k and $\varepsilon = \varepsilon(x_{it}, t; \beta) = \sum_k \varepsilon_k(x_{it}, t; \beta)$ provides a measure of a firm's returns to scale.

$\sum_k \left[(\frac{\varepsilon_k}{\varepsilon}) - S_k \right] \overset{\circ}{x}_k$ measures allocative inefficiency, or the deviation of input prices from their marginal products. Where $S_k = \frac{w_k x_k}{E}$ is a measure of the expenditure share of input k, w_k is the unit price of input k and $E = \sum_k w_k x_k$ is total expenditure in inputs.

$TE\Delta = -\frac{\partial u_{it}}{\partial t}$ is the primal measure of the rate of change in technical efficiency.

3. Empirical implementation

To analyze the efficiency and productivity of the Spanish farms specialized in the production of oranges and to decompose the evolution of productivity growth for this product in recent years, we use FADN (Farm Accounting Data Network) data base from the period 1995-2003.

FADN was launched in 1965. It consists of an annual survey carried out by the Member States of the European Union. It provides representative data of EU agricultural holdings along three dimensions: region, economic size and type of farming. It should be noted however, that FADN only considers "professional" holdings with enough size to constitute the grower's principal activity and provide enough revenue to meet his household needs. As a result, FADN data only represents about 65% of the Spanish holdings. A summary of the main characteristics of the citrus farms according to FADN dataset is listed in Table 1.

Table 1. *Main characteristics of FADN data base*

	Specialist fruit and citrus fruit		
	1994-1995	1998-1999	2002-2003
I. Generals Characteristiques			
Total Utilised Agricult. Area-ha	7.6	7.5	7.3
Rented U.A.A.-ha	0.1	0.4	0.6
UAA irrigated	7.6	7.5	5.4
Total labour input-AWU	0.8	1.0	1.1
Unpaid labour input-FWU	0.6	0.7	0.9
II. Production			
Total output-Euro.	11689	18677,5	22745,5
Fruit-Euro.	4726,5	11978	12051,5
Citrus fruit-Euro.	6254,5	5100,5	8834,5
III. COSTS			
Total Inputs-Euro.	6940	9480	10154
Total intermediate. consumption.-Euro.	3435,5	4887	5952,5
Total specific costs-Euro.	1950	2482	2952,5
Fertilisers-Euro.	873,5	1029,5	1178
Crop protection-Euro.	1032	1208	1402
Total farming overheads-Euro.	1485,5	2404,5	2999,5
IV. INCOME			
Gross Farm Income-Euro.	9191	15355,5	17986,5
Farm Net Value Added / AWU-Euro.	9084,5	13510,5	14805
Farm Net Value Added-Euro.	7255,5	13601,6	16667,5
Family Farm Income-Euro.	5674,5	10660,5	13781,8

Source: EU-FADN-D G Agriculture and Rural Development G-3.

Since FADN farms producing Oranges are aggregated into wider specialist groups (citrus fruits), we choose to select farms according to the following rule. Specialist Orange: we select farms whose Orange sales represent more than 70% of citrus sales[1]. The obtained selection is a panel data comprising years from 1995 to 2003.

Also, we use other data taken from the Spanish Ministry of Agriculture and Eurostat. Market prices variables required to carry out the total factor productivity

[1] It is also relevant to note that orange area represents more than 50% of total citrus area (FADN data set)

growth decomposition are not available in FADN dataset. Therefore, to define the price of pesticide, fertilizer and other variable input prices as well as the output price index, we use national price indices (base 1995) taken from Eurostat. The Spanish Ministry of Agriculture provided land prices at the national level. Labour prices are approximated at the farm-level by dividing a farm's labour expenses by the hours of labour.

Our sample is composed by 859 observations for citrus farms specialist in orange production, which constitute an unbalanced panel data. The use of a panel data in efficiency estimation offers advantages over a cross section, since it allows technical efficiencies to change both as a result of individual characteristics as well as a result of time variation.

The production frontier function is specified as a Cobb-Douglas with no neutral technical change function that takes the form:

$$y_{it} = \beta_0 e^{\beta_t t} \prod_{k=1}^{K} x_{it}^{(\beta_k + \beta_{kt} t)} e^{v_{it} - u_{it}} \tag{6}$$

Production, y_{it}, is defined as an implicit quantity index by dividing total oranges sales in currency units by the orange price index. Vector x_{it} is defined as a (1×4) vector that contains four inputs. β is a $(K \times 1)$ vector of unknown parameters to be estimated, and the disturbance term is composed of two parts: v_{it} and u_{it}.

The first input, x_1, includes fertilizers and pesticides, x_2 comprises variable specific inputs other than fertilizers and pesticides, x_3 represents the hectares occupied by olive groves and x_4 represents labor input and is measured in labor hours per year. Input use variables x_1 and x_2 are expressed as implicit quantity indices by dividing the consumption of these inputs in currency units by their respective price indices.

All variables in the stochastic frontier are normalized with respect to their own mean and transformed to their logs in the estimation process. The parameters of the stochastic production frontier model are estimated by using the maximum likelihood method and the FRONTIER (version 4.1) program developed by Coelli (1992) that provides also estimates of output oriented technical inefficiency. The TFP growth is decomposed using SAS.9.

Several hypotheses can be tested by using the generalized likelihood-ratio statistic, $\lambda = -2\{\ln L(H_0) - \ln L(H_1)\}$, where $L(H_0)$ and $L(H_1)$ denote the values of the likelihood function under the null (H_0) and the alternative (H_1) hypothesis, respectively[2]. First, if $\gamma = \mu = \xi = 0$ technical inefficiency effects are non-stochastic and (3) reduces to the average response function in which the explanatory variables in the technical inefficiency model are also included in the production function. Second, if $\mu=\xi=0$ the technical inefficiency is time-invariant given the stochastic frontier model. Third, if μ=0 the stochastic frontier model with time-varying output-oriented technical efficiency and that the inefficiency effects have half- normal distribution. Fourth, ξ=0 that time-invariant output-oriented technical efficiency.

Fifth, if $\sum_j \beta_j = 1$ and $\sum_j \beta_{jT} = 0$, the constant return to scale, and finally, if $\beta_{jT} = 0\ \forall j$ and $\beta_T = \beta_{TT} = \beta_{jT} = 0\ \forall j$, zero and hicks neutral technical change.

4. Estimation and results

Results derived from estimating the Cobb-Douglas with no neutral technical change production frontier, output elasticity, technical efficiency scores, and model specification tests for citrus farms are presented in tables 2, 3, 4 and 5.

First-order parameters, β_k , are all positive and statistically significant thus indicating that production is increasing in all inputs: pesticides and fertilizers, other variable inputs, land and labour (Table 2). Variance parameters, *γ,* are statistically significant and relatively close to one, which suggests the relevance of technical inefficiencies in explaining output behaviour for our farms sample. It also suggests that one should not rely solely on the average production function response as an adequate representation of the data sample. The parameter ξ captures the temporal variation of individual output-oriented technical efficiency ratings. The parameter ξ is positive and statically significant, so, technical efficiency tends to improve over time.

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[2] If the given null hypothesis is true, the generalized likelihood-ratio statistic has approximately a χ^2 distribution, except the case where the null hypothesis involves also $\gamma = 0$. Then, the asymptotic distribution of λ is a mixed χ^2 (Coelli, 1995) and the appropriate critical values are obtained from Kodde and Palm (1986).

Table 2. *Maximum Likelihood Estimates of a Cobb-Douglas Production Frontier Function for citrus farms in Spain, 1995-2003*

Parameter	Estimate	Standard Error
α_0	0.6038	(0.0395)*
α_K	0.3242	(0.0738)*
α_L	0.1841	(0.0370)*
α_F	0.2201	(0.0362)*
α_O	0.1040	(0.0279)*
α_{KT}	-0.0586	(0.0610)
α_{LT}	0.1304	(0.0386)*
α_{FT}	0.0609	(0.0348)*
α_{OT}	-0.0060	(0.0312)
α_T	-0.2628	(0.0460)*
α_{TT}	-0.2330	(0.0330)*
σ_u^2	3.2963	(0.5244)*
γ	0.9636	(0.0066)*
ξ	0.0270	(0.0080)*

Note: *L* refers to labour, *K* to Land, *F* to Fertilizers and *O* to other costs.
* indicate that the parameter is significant at 5%.

Results also suggest a decrease of productivity levels of the land input through years, which may be due to the relevance of extensive production methods, which offers scope for future improvements through the use of better practices and techniques. On the other hand, labour, fertilizers and pesticides inputs present improvement of productivity along years (Table 3).

Table 3. *Output Elasticities for Spain citrus-Growing Farms, 1995-2003*

	1995	1996	1997	1998	1999	2000	2001	2002	2003
Output Elasticities									
Land	0.416	0.376	0.352	0.335	0.322	0.311	0.302	0.294	0.287
Labour	-0.02	0.068	0.121	0.159	0.188	0.212	0.232	0.249	0.265
Fertilizers & pesticides	0.124	0.166	0.191	0.208	0.222	0.233	0.242	0.250	0.257
Other costs	0.113	0.109	0.106	0.105	0.103	0.102	0.101	0.101	0.100

Table 4 presents the test results of various null hypothesis on the total sample. We use the generalized likelihood-ratio statistic to test for the null hypothesis that inefficiency effects are absent from the model, i.e., $\gamma = \mu = \xi = 0$. Results indicate that the null hypothesis is rejected for citrus farms at 5% significance level for total sample, confirming that citrus Spanish farms suffer from inefficiencies. The second tested null hypothesis, that technical inefficiency is time-invariant given the stochastic production frontier model ($\mu=\xi=0$) is also rejected at the 5% significance level for the total sample. This implies that technical inefficiency in Spanish citrus farms is not time-invariant, given the time-varying specification of the stochastic frontier defined by equation (4). The third tested hypothesis, that the stochastic frontier model with time-varying output-oriented technical efficiency and that the inefficiency effects have half-normal distribution, ($\mu=0$) is also rejected at the 5% significance level for the total sample which the inefficiency effects don't have half- normal distribution The fourth tested hypothesis, that time-invariant output-oriented technical efficiency ($\xi=0$) is rejected at the 5% significance level for the total sample. This implies that output-oriented technical efficiency is time variant.

The hypothesis of the presence of constant returns to scale ($\sum_j \beta_j = 1$ and $\sum_j \beta_{jT} = 0$) is tested for the citrus farms using the generalized likelihood ratio statistic and the null hypothesis is rejected at the 5% significance level for the total sample. Thus, there are decreasing returns to scale, making an increase in the farm size unattractive.

Both the sixth and the last null hypothesis, that there is zero and hicks neutral technical change in Spanish citrus farms ($\beta_{jT} = 0\ \forall j$ and $\beta_T = \beta_{TT} = \beta_{jT} = 0\ \forall j$), are rejected at the 5% level for the total sample. This implies the existence of non-neutral progress in Spanish citrus farms as a whole, given the specified production model.

Table 4. *Model Specification Tests for citrus farms.*

Hypothesis	LR test-statistic	Critical Value (a=0.05)
Average Production Function, *i.e.*, $\gamma=\mu=\xi=0$	950.54	$\chi_3^2 = 7.81$
Aigner *et al.*, (1977) SPF model with time-invariant output-oriented technical efficiency, *i.e.*, $\mu=\xi=0$	32.53	$\chi_2^2 = 5.99$
Aigner *et al.*, (1977) SPF model with time-varying output-oriented technical efficiency, *i.e.*, $\mu=0$	22.61	$\chi_1^2 = 3.84$
Time-invariant output-oriented technical efficiency, *i.e.*, $\xi=0$	10.18	$\chi_1^2 = 3.84$
Constant returns-to-scale, *i.e.*, $\sum_j \beta_j = 1$ and $\sum_j \beta_{jT} = 0$	12.84	$\chi_5^2 = 11.1$
Hicks-neutral technical change, *i.e.*, $\beta_{jT} = 0\ \forall j$	12.55	$\chi_4^2 = 9.49$
Zero-technical change, *i.e.*, $\beta_T = \beta_{TT} = \beta_{jT} = 0\ \forall j$	64.17	$\chi_6^2 = 12.6$

The obtained results demonstrate that the predicted technical efficiencies take an average value of 64.11% through the period studied for Spanish citrus farms (Tables 5), with 38% of farms in the sample attended a score greater than 80%. A majority of farmers (74% of the sample) have efficiency scores above 60%. Efficiency levels below 100% suggest that production, on average, could further increase through more efficient use of inputs in sector.

Table 5. *Measures of Technical Efficiency for Spanish citrus farms, 1995-2003*

TE	95	96	97	98	99	00	01	02	03
<20	4	8	10	7	7	7	5	8	5
20-30	2	7	7	3	5	7	4	2	1
30-40	10	9	8	5	6	1	3	4	4
40-50	3	13	10	9	8	7	8	6	6
50-60	15	12	13	9	7	8	9	9	8
60-70	10	12	10	11	12	10	7	6	6
70-80	16	16	17	16	15	15	14	15	13
80-90	23	28	29	29	32	32	32	32	32
90>	4	6	6	5	7	7	8	7	6
Mean	63%	60%	60%	64%	64%	64%	67%	66%	69%

The evolution of technical efficiencies during the period of study shows an efficiency improvement for citrus farms that move from 53% in 1995 to 69% in 2003. This result is confirmed with the positive value of parameter ξ that indicate that technical efficiency tends to improve over time. The tendency of improvement of technical efficiency score along the period studied suggest that Spanish citrus have improved the use of inputs in citrus sector.

Results of the TFP growth decomposition are reported in Table 6. As noted above, the TFP increases can be decomposed into technical, scale, technical efficiency and allocative inefficiency changes. The decomposition of TFP growth suggests a positive evolution characterizing the citrus sector by a 2.7% along the period studied, since increases in production are achieved through improvements in technical efficiency change, allocative efficiency and scale component. However, technical change has a negative impact.

Allocative efficiency is the most important component on productivity growth (2.3%) following by both technical efficiency change (0.321%) and scale component (0.1%). Technical change has a weak negative impact on TFP growth (-0.015%).

Table 6. *Decomposition of TFP Growth for Spanish citrus Farms (average values for the 1996-03 period)*

	TFP	TEC	SC	AE	TC
1996	0.024222	0.005057	-0.00792	0.027073	0.000012
1997	0.145540	0.002790	0.021737	0.121088	-0.000074
1998	0.092292	0.004003	-0.03599	0.12438	-0.0001005
1999	0.025411	0.001828	0.030043	-0.00632	-0.000139
2000	0.0754524	0.005234	-0.015332	0.085737	-0.000185
2001	-0.031069	0.001128	0.018885	-0.05086	-0.000222
2002	-0.146991	0.002837	0.008711	-0.15828	-0.000259
2003	0.0369498	0.002598	-0.011398	0.046036	-0.000285
1999-2003 average	0.0277259	0.0031843	0.0010918	0.0236067	-0.000157

The evolution along period studied shows that they have an improvement of technical efficiency of Spanish farms with a peak in 1996 and 2000. The scale component show a fluctuation from 1996 to 2003 due to decreasing return to scale that characterize the production function, which prevent a clear improvement of scale economies. On the other hand, allocative efficiency follows a fluctuation along years which imply that the Spanish citrus farms takes an advantage or waste following the deviation of the input prices from their marginal product. The technical change evolution decrease along time, with the exception of the first year. This results support the technical change coefficient estimated in the production function that show a negative impact of technical change on the production, which could be caused by a decrease in orange prices.

Conclusion

This paper analyzes technical efficiencies and factor productivity changes for a sample of Spanish farms specialized in citrus production with large production in oranges. We estimate a stochastic frontier model to analyze technical efficiencies and decompose the productivity growth into its various components. An unbalanced panel of 859 observations is used in the empirical analysis.

Our main conclusion is that the Spanish citrus sector production function is characterized by a decreasing return to scale, making the increase of farm size unattractive. So, the sector should be more concentrated in order to avoid loss of bargaining power facing the distribution chains, and to obtain a sufficient return to scale.

The analyses of technical efficiency of Spanish citrus farms show an improvement along the studied period going from 53% in 1995 to 69% in 2003. The estimated average efficiency level for our farms sample is about 64.11% with 38% of farms in the sample attended a score greater than 80%. This results show that, the fact to belong to the EU markets and the favourable climatic condition, have allowed the Spanish citrus farms to become more competitive and improve its efficiency along years.

For productivity growth, results show a positive evolution characterizing the citrus sector by a rate of 2.7% along the period studied, since increases in production are achieved through improvements in technical efficiency change, allocative efficiency and scale component. However, technical change has a negative impact. This decrease in technical change confirm the negative effect of time trend on production function, which could be explained principally by two reasons: A relevant decrease in orange prices during the second half of 1990s may have discouraged investments during this period of time.

Moreover, a decline of the orange consumption in all developed countries due to improvements in transportation and storage has favoured wider and longer availability of other substitute fruits. This may suggest the need for implementing policies oriented towards product differentiation to add more value in order to obtain more attractive prices, and therefore re-stimulate investments in the sector. Also, there is a need for an improvement of the support scheme to be reoriented towards the industry sector. This could allow stimulating the citrus-processing industry sector and the mobilisation of farmers to joint the producer organizations.

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