TECHNICAL EFFICIENCY IN THE MEDITERRANEAN COUNTRIES' AGRICULTURAL SECTOR

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Abstract – *This paper aims to estimate the technical efficiency of the agricultural sector in a group of Mediterranean countries involved in the process of global market liberalization. The analysis applies the stochastic production frontier model to a set of six different crop products. For each product, a panel data set covering the period 1990-2005 in fourteen Mediterranean countries is used and separate econometric results are obtained. Then cross-sectional country information* ***is*** *used, in the second stage, to assess the main factors contributing to technical inefficiencies and to explain efficiency differentials among Mediterranean countries. The empirical results revealed the presence of important inefficiencies in Mediterranean agricultural production with significant diversities across countries and crops. EU countries on average appear to have higher technical efficiency levels than SMC, among which some states such as Algeria, Morocco, Tunisia and Jordan display substantial misallocation of resources. The results indicate that there exists scope for increasing crop production up to 50% in some regions through expanding irrigated areas, encouraging the mechanisation of the farmers and combating the land fragmentation.*

Key Words: TECHNICAL EFFICIENCY, AGRICULTURE, FRONTIER PRODUCTION FUNCTION.

JEL Classification: C23, F12, F13, L15, Q17.

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1. INTRODUCTION

The Barcelona conference, held during November 1995, led to the negotiation and signature of partnership agreements between the European Union (EU) and several Southern Mediterranean Countries (SMC). The ambitious aim of the Barcelona declaration was to achieve a greater economic integration in the Mediterranean region through the gradual establishment of a free trade Euro-Mediterranean area by 2010.

The association arrangements, currently limited to the removal of tariff and non-tariff barriers on manufactured goods, are going to be enlarged to agricultural products. The debates over the progressive liberalization of farming products are still underway (Legrand, 2002; CIHEAM, 2002, 2005; Corrons et al., 2004; Bouët et al., 2004)

Agriculture, considered as a vital sector in the SMC, is expected to face ambitious challenges and interesting perspectives by the increasing openness of these economies

SMC enjoy a good potential in agricultural trade due to favorable climatic conditions, competitive advantage of cost of production, especially labor, and closeness to the EU markets. South Mediterranean governments implemented important agricultural development projects directed towards modernizing the agricultural sector and enhancing the efficiency and quality in the vegetal production. The government's strategies placed an increased emphasis on promoting relatively high value export goods like citrus, some fresh fruits and vegetables, wines and olive oil… at the expense of the more traditional farming productions (CIHEAM, 2002, 2005). These policies aggravated the heterogeneity that characterizes the SMC agricultural sectors, where a modern export oriented agriculture which mobilizes an important fraction of fertile lands and irrigation water, is combined with poor traditional farming mainly based on rain fed production systems and particularly vulnerable to irregular weather conditions. Rain fed agriculture represents the essential economic activity in the rural areas and suffers from the use of traditional practices, the lack of logistic and human skills, the weak productivity and the low quality of its products. This sector appears to be particularly sensitive to agricultural trade liberalization since the rural farmers may have severe difficulties to sustain competition from the more efficient EU producers (Corrons, 2000; Corrons et al., 2004)

Several empirical studies using applied general equilibrium models showed that a free trade policy can substantially boost the Mediterranean agricultural exports, with a wide expansion of the products having appreciable comparative advantages. They concluded that the opening process should be carried out with accompanying policies for restructuring the rural sector to cope with the fierce international competition (Chemengui and Dessus, 1999; Corrons, 2000; Jabarin, 2001; Muaz, 2004).

In the coming years, therefore, one important policy issue for the SMC will be to make the whole agricultural sector more competitive, to increase efficiency in the farming sector and to enhance the rational utilization of scarce natural resources, mainly water and land.

SMC share some common features like environmental conditions, agricultural practices and cropping patterns and face similar policy and institutional challenges. They differ nevertheless in their resource endowments and their ability to meet food import requirements. These countries are expected to be affected in different ways by the free trade policy; their capacity to benefit from opportunities arising from the new trade environment being closely related to the performance of their agricultural sector. In this context, assessing the SMC's agricultural performance and their potential to compete with Mediterranean EU countries may be a useful tool for policy analysis and decision making.

The following analysis depicts farming performances through the productive efficiencies in the agricultural sectors of a panel of advanced and developing Mediterranean countries involved in the process of global market liberalization, and investigates the factors contributing to productivity improvement in these countries using the stochastic frontier models.

Since the seminal paper by Farrell (1957), extensive empirical research has been conducted on efficiency measurement in agricultural economics. Farrell's approach is based on the comparison between observed production and best-practice or frontier production. At any point of time a production frontier reveals the state of a certain technology that determines the maximum feasible output from the actual bundle of inputs. A farm producing beneath this frontier is considered as technically inefficient in its resource utilization. Technical efficiency is, therefore, calculated through the ratio of observed production to the corresponding maximum output given by the production frontier. This efficiency notion accounts for all producible outputs and all types of inputs but it only provides a scalar measure of technical efficiency which gives little information about the improper use of specific inputs. Several econometric studies have attempted to examine the sources of technical inefficiency by the regression of technical efficiency indexes on a set of explanatory variables that affect the managerial ability of farming such as age and education, inputs quality and factor endowment (Pitt and Lee, 1981; Bravo-Ureta and Pinheiro, 1993; Ferrantino and Ferrier, 1995; Hallam and Machado, 1996; Alvarez and Gonzalez, 1999; Iraizoz et al., 2003). These studies use the Stochastic Production Frontier models. The causes of technical inefficiency are investigated by a two-step procedure which first estimates the relative efficiencies using the stochastic frontier, and then analyses the effects of the exogenous farm-specific factors on efficiency.

Stochastic frontier models have been extensively applied in the past mainly at a micro level, but have gradually gained popularity in macro economic analysis in recent years. The number of studies investigating cross-country differences in agricultural productivity levels and growth rates has significantly expanded during the past decades, (Kawagoe and Hayami, 1985; Lau and Yotopoulos, 1989; Fulginiti and Perrin, 1998; Rao et al., 2004). This is most likely driven by the availability of some new panel data sets, such as that produced by the Food and Agriculture Organization of the United Nations (FAO) and the development of new empirical techniques to analyze this type of data, such as the data envelopment analysis (DEA) and stochastic frontier analysis (SFA) techniques (Coelli et al., 1998). The majority of these studies focus generally on the estimation of the production elasticities and the investigation of the factors contributing to productivity differentials considering one aggregate agricultural output as a dependent variable.

Aggregating multiple products into a single output may however prevent the exploration of the efficiency differences that may exist among various commodity groups. As far as we know, no studies have been devoted to depict agricultural efficiency for the Mediterranean region using disaggregated outputs.

The present study applies the stochastic production frontier model to a set of six different Mediterranean crop groups (fruits, shell-fruits, citrus fruits, vegetables, cereals and pulses). The analysis employs a two-step approach which combines cross-sectional and panel data for the estimation of technical efficiency indexes in the agricultural sectors of nine South Mediterranean Countries: Algeria, Tunisia, Morocco, Lebanon, Turkey, Jordan, Syria, Egypt and Israel; and five Mediterranean European Union Countries: France, Spain, Italy, Greece and Portugal. In the first stage, separate production elasticities and efficiency indexes are obtained for each product group and each country using a panel data set covering the period 1990-2005. Then cross-sectional country information is used, in the second stage, to assess the main factors contributing to technical inefficiencies and to explain productivity differentials among Mediterranean countries. The results obtained from the second step regression help to compute corrected technical efficiency indexes.

The paper is organized as follows: section 2 outlines the stochastic production frontier model and the specification used to estimate technical efficiency indexes followed by the procedure used to explain the inefficiency effects. Section 3 provides an overview of the data used and reports the main econometric results. Section 4 summarizes the essential findings and conclusions.

2. TECHNICAL EFFICIENCY AND EXOGENOUS INFLUENCES

This section focuses on estimating technical efficiency indexes in the agricultural sector of some Mediterranean countries, and analyzing the main factors contributing to inefficiencies. The analysis uses a two-stage procedure. A conventional index of technical efficiency is estimated in the first stage using Stochastic Production Frontier models. The estimated indexes are then adjusted using cross sectional country information to assess the main factors contributing to technical inefficiencies.

2.1. Technical efficiency measurement

The Stochastic Production Frontier models (SPF) developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) has propelled a vast amount of applied works on the econometric estimation of technical efficiency (Coelli and Battese, 1996; Pascual, 2001; Iraizoz et al., 2003; Joshua, 2005). This approach assumes that the gap between current and best practice may not be completely under the producer's control, and allows for the introduction of statistical noises resulting from random events such as weather conditions and equipment failures (Green, 1993).

The SPF is based on a parametric specification of the technology with inefficiency effects. The disturbance term in a regression of output-input relationship is considered as composed of two elements: a symmetrical error term (ε) that accounts for random effects and assumed to be independently and identically distributed as $N(0,\sigma_\varepsilon^2)$; and a one-sided non-negative random disturbance (v) which represents systematic effects that are not explained by the production function and therefore considered as technical inefficiency. By decomposing the error term, the frontier production function can be expressed as:

(1) $y_i = \alpha + x_i\beta + \varepsilon_i - v_i$

where y_i is the output of country i, x_i the vector of inputs and α and β are parameters to be estimated.

The stochastic frontier of equation (1) was extended to accommodate panel data by Pitt and Lee (1981) and Schmidt and Sickles (1984). The panel data model can be written as:

(2) $y_{it} = \alpha + x_{it}\beta + \lambda_t + \varepsilon_{it} - v_i$

where λ_t is the time effect. The inefficiency term can be fused with the constant, by setting $\alpha_i = \alpha - v_i$, to obtain a standard panel data model:

(3) $y_{it} = \alpha_i + x_{it}\beta + \lambda_t + \varepsilon_{it}$

Where α_i can be estimated by the fixed or random effect estimator, according to the correlation between the individual effects and the explanatory variables (Alvarez and Gonzalez, 1999; Wang and Schmidt, 2002; Green, 2003).

The relative indexes of technical efficiency are then computed from the comparison of the estimated α_i for each country to its maximum estimated value. For a logarithmic specification, these indexes are measured as follows:

(4) $TE_i = \exp(\alpha_i - \max \alpha_j)$

where TE_i is the technical efficiency level of country i. TE_i takes the value 1 for the country with the largest individual effect, which is considered as producing on the production frontier and is said to be technically efficient, the remaining countries operating at some level of inefficiency obtain indexes lower than 1.

To make the economic model suitable for econometric analysis it is convenient to approximate the frontier production in (3) by a flexible mathematical function such as the translog form. The model to be estimated takes then the following form:

$$(5) \qquad Ln(y_{it}) = \alpha_i + \sum_j \beta_j Ln(x_{jit}) + \frac{1}{2}\sum_j \sum_k \beta_{jk} Ln(x_{jit}) Ln(x_{kit}) + \upsilon_{it}$$

where $\beta_{jk} = \beta_{kj}$ for $j \neq k$, the subscripts i and t refer to the i^{th} country and t^{th} period respectively, j and k represent inputs.

2.2. Determinants of technical efficiency and adjusting procedure

Measuring technical efficiency by individual effects can be misleading since this approach fails to disentangle heterogeneity unrelated to efficiency from the inefficiency itself. This ambiguity is likely to be particularly problematic in analysis based on aggregate country-level data, as the broad variation in the countries economic characteristics leads to a substantial unmeasured heterogeneity in the data (Greene, 2003).

Alvarez and Gonzalez (1999) performed a two-stage procedure for adjusting technical efficiency indexes from the heterogeneity captured by the fixed effects in a model applied to Spanish dairy farms. Their approach uses cross-sectional information on a farm's characteristics to estimate corrected technical efficiency indexes using panel data.

Following these authors, we assume that the heterogeneity captured by the fixed effect can be adjusted by complementary information about the specificities of countries. A large individual effect implies that there are unobservable factors that make one country more productive than another. Our intent is to disentangle the part of individual effect due to management from the part attributed to complementary factors. The methodology consists in regressing the estimated fixed effects on a set of explanatory variables reflecting countries characteristics:

$$(6) \qquad \hat{\alpha}_i = \delta_0 + \sum_j \delta_j z_{ji} + \omega_i$$

where z_{ji} are countries specific variables and ω_i a random variable

The fitted value $\tilde{\alpha}_i$ is corrected by the largest positive residual to yield:

$$(7) \qquad \alpha_i^* = \tilde{\alpha}_i + \max \hat{\omega}_j$$

The adjusted index of technical efficiency uses α_i^* to yield:

(8) $TE_i^* = \exp(\hat{\alpha}_i - \max \alpha_j^*)$

3. DATA AND EMPRICAL RESULTS

3.1. Data

The empirical application in this study considers panel data at the national level for agricultural productions in nine SMC involved in the partnership agreements with the EU such as: Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, Tunisia and Turkey and five EU Mediterranean countries presenting a strong potential in agricultural production as: France, Greece, Italy, Portugal and Spain for the period 1990-2005. The data we use come from the FAO (FAOSTAT), World Bank, AOAD and Eurostat databases as well as from the different reports of the FEMISE and the ESCWA. Our data set includes observations on the main crops grown in these countries, the inputs that are used and countries' characteristics. The model comprises some non observable explanatory variables; we approximate these variables by available proxies. The variables used in the empirical analysis are summarized as follows:

– *Output and input:* we considered six aggregate product categories: fruits (apricots, dates, figs, peaches and nectarines, pears, apples, plums, grapes), shell-fruits (almonds, peanuts, hazelnuts, pistachios), citrus fruits (lemons, oranges, tangerines, other citrus fruits), vegetables (artichokes, carrots, cucumbers and pickles, strawberries, watermelons and melons, pepper, potatoes, tomatoes), cereals (rice, wheat, maize, barley) and pulses (beans, peas, chick-peas, lentils, vetches). Inputs are classified into five groups: cropland, irrigation water, fertilizers, labor and capital. The data for the input use by crop for each country are constructed according to the information collected from recently published reports by FAO, FEMISE, ESCWA and the Ministries of Agricultural in the considered countries. Labor is calculated in terms of days worked for each of the selected crops, cropland is calculated in hectares of utilized agricultural area, capital is measured in terms of hours of machines used, fertilizers are evaluated by kilograms used and water is calculated by cubic meters allocated for each crop. Table A1 in the appendix presents summary statistics on the sample.

– *Country characteristics:* we use variables on the agricultural productive capacity of each country such as: agricultural land area, part of irrigated area, water resources and agricultural machinery; environmental variables as: average precipitations and part of agricultural area incurring severe and very severe degradation; and land fragmentation evaluated by the part of exploitations having an area under five ha. Country statistics are summarized in table A2 in the appendix.

3.2. Empirical results

Equation (5) was computed by OLS using the WITHIN estimator for a fixed-effects model. We applied White's estimator of the variance-covariance matrix to correct for heteroskedasticity. We achieved different groups of estimations: we started with appraising input elasticities from the translog production function using data for each group of products on the panel of the considered countries, and then we stacked the different groups in one model. Table 1 summarizes the inputs elasticities evaluated at the geometric mean of the sample. The elasticities are globally positive and significant at the 5% level. Water, cropland and labour have globally the largest values, indicating that the increase in Mediterranean agricultural productions depends mainly on these inputs. Fertilizers have a limited effect in the production of selected crops. Except for cereals and pulses groups, the fertilizers elasticity is weak and rarely significant, this may be explained by the fact that the selected crops are not very intensive in fertilizers; moreover, several farmers in SMC use fertilizers as a complementary factor to organic manure which is much less expensive. Water and labour appear as the most important factors in citrus fruits and vegetables productions, these crops being highly water and labour intensive. Fruits and shell-fruits are on the other hand capital intensive. Cropland seems to be the main factor in the production of cereals and pulses since these commodities require large agricultural plots.

Table 1: Estimates of the input elasticities

	Total	Fruits	Citrus	Shell-fruits	Vege-tables	Cereals	Pulses
Cropland	0.21**	0.19**	0.29**	0.28**	0.26**	0.49**	0.48**
Water	0.37**	0.12**	0.43**	0.16*	0.75**	0.08*	0.07*
Fertilizer	0.037*	0.036	0.05	0.09	0.06**	0.23*	0.34**
Labour	0.28**	0.24**	0.35*	0.23**	0.38**	0.03*	0.08*
Capital	0.19**	0.29**	0.12*	0.26*	0.01	0.09**	0.1
R^2	0.96	0.96	0.95	0.89	0.98	0.97	0.93

** and ** indicate significance at the 5% and at the 1% levels respectively.*

Relative indexes of technical efficiency are computed from the comparison of the estimated individual effects as in equation (4). The results are reported in table 2, yielding mean technical efficiency equal to 0.6 with a standard deviation of 0.23. Significant differences among crops and countries can be noticed. On average, over the period under consideration, EU countries exhibited higher technical efficiency indexes than SMC. It emerges from the results that Turkey, followed by France, Italy and Spain appear as the most efficient countries, their average efficiency index varying between 74% and 85%. Greece, Lebanon, Israel, Egypt and Syria seem to be operating at a middle efficiency level ranging between 50% and 70%. Algeria, Morocco, Tunisia, Jordan and Portugal suffer from enduring substantial inefficiencies in their farming operations, since their relative efficiency index is inferior to 50%.

The results indicate that SMC are more efficient in fruits, citrus and vegetables productions than in shell fruits, cereals and pulses. Among these countries, Turkey followed by Lebanon and Morocco appear as the most efficient countries. EU countries on the other hand seem to be highly efficient in vegetables and cereals cropping. France and Spain show the greatest efficiency indexes in these productions.

Table 2: Technical efficiency indexes

	Total	Fruits	Citrus	Shell-fruits	Vege-tables	Cereals	Pulses
Algeria	0.34	0.61	0.17	0.68	0.54	0.63	0.28
Spain	0.61	0.71	1	0.69	1	0.91	0.23
France	0.85	0.96	0.13	0.33	0.97	1	1
Greece	0.74	0.72	0.98	0.39	0.76	0.82	0.45
Italy	0.78	0.69	0.95	0.68	0.88	0.73	0.48
Portugal	0.28	0.34	0.29	0.15	0.55	0.54	0.25
Israel	0.75	0.72	0.57	0.79	0.43	0.57	0.43
Jordan	0.45	0.45	0.43	0.28	0.6	0.33	0.26
Lebanon	1	1	0.65	0.58	0.39	0.59	0.61
Morocco	0.34	0.37	0.88	0.28	0.74	0.32	0.32
Syria	0.65	0.5	0.53	0.75	0.51	0.39	0.39
Tunisia	0.38	0.35	0.33	0.21	0.57	0.68	0.38
Turkey	0.87	0.89	0.81	1	0.99	0.88	0.53
Egypt	0.49	0.77	0.43	0.32	0.66	0.61	0.48

The determinants of efficiency differentials among the selected countries are investigated through the regression of the efficiency indexes on a set of explanatory variables representing some countries characteristics. The variables used are soil quality measured by the part of agricultural land incurring severe and very severe degradation, agricultural land size which reflects the country's production capacity, the part of irrigated area which measures the country's production capacity of irrigated crops, the climate evaluated by average rainfall, agricultural machinery to approximate the degree of agricultural sector mechanisation, land fragmentation measured by the part of exploitations having an area under five hectares and country's total water resources to reflect the availability of irrigation resources.

The estimation results are reported in table 3. The estimated coefficients globally have the expected signs and are significantly different from zero. Average precipitations, irrigated areas, agricultural machinery and land size have a positive impact on the efficiency of resources use while water availability and land fragmentation enhance inefficient behaviour. Soil quality does not seem to have a significant impact on technical efficiency. The positive correlation between agricultural machinery and efficiency reveals that mechanized farmers are more efficient and modernizing the agricultural sector can contribute to promoting the productivity of the sector. The positive impact of precipitations on efficiency can be explained by the fact that an important part of cereals and pulses, some fruits and shell fruits are produced in rain fed areas. These commodities are particularly sensitive to weather conditions and to the lack of rainfall characterizing the Mediterranean climate. An increase in rainfall can then contribute to a substantial rise in productivity and efficiency. Wider irrigated areas affect efficiency favourably, since irrigation is considered as a risk-reducing input that tends to increase mean yield and reduce its variability when rainfall is inadequate. Agricultural land size has a positive but limited impact on efficiency, this result may be explained by the fact that countries with higher agricultural areas by exploring scale economies tend to be more efficient than those suffering from narrow farming areas.

The availability of water resources seems on the other hand to encourage the waste of resources as it has a negative impact on efficiency. Land fragmentation is also negatively correlated with efficiency. Land fragmentation may lead to sub-optimal usage of factor inputs due to inadequate monitoring, the inability to use certain types of machines, and wasted space among borders[1]. A high percentage of land fragmentation may also reflect the existence of an important number of small farms with limited financial resources, low skills and inefficient traditional production methods.

Table 3: Estimation of the second stage regression

	Coefficient	t-ratio
Soil quality	0.24	1.56
Average precipitations	0.62**	4.4
Water resources	-0.49**	-7.98
Agricultural machinery	0.13**	3.19
Land fragmentation	-0.14*	-2.48
Part of irrigated area	0.24**	3.3
Agricultural land size	0.04*	1.92
R^2	0.45	

The second stage regression allowed the evaluation of efficiency indexes adjusted by the countries' heterogeneity according to equation (8) of the model. The results are presented in table 4. The adjusting procedure leads to relatively similar results to those obtained in table 2. These results reveal that the observed heterogeneity between Mediterranean countries is mainly explained by the differential in resource management between these countries.

Table 4: Adjusted Technical Efficiency Indexes

	Total	Fruits	Citrus	Shell-fruits	Vege-tables	Cereals	Pulses
Algeria	0.31	0.55	0.19	0.49	0.42	0.65	0.32
Spain	0.59	0.64	0.86	0.43	0.79	0.68	0.25
France	0.79	0.99	0.12	0.25	0.9	0.98	1
Greece	0.65	0.76	0.85	0.27	0.52	0.71	0.53
Italy	0.71	0.98	0.8	0.68	0.92	0.75	0.56
Portugal	0.25	0.31	0.21	0.15	0.43	0.59	0.3
Israel	0.71	0.75	0.63	0.66	0.54	0.72	0.75
Jordan	0.51	0.46	0.26	0.29	0.69	0.42	0.44
Lebanon	0.97	0.95	0.5	0.6	0.44	0.45	0.48
Morocco	0.32	0.34	0.67	0.21	0.58	0.38	0.34
Syria	0.61	0.45	0.4	0.67	0.47	0.49	0.51
Tunisia	0.35	0.32	0.26	0.38	0.45	0.76	0.36
Turkey	0.85	0.96	0.84	0.95	0.98	0.93	0.63
Egypt	0.46	0.69	0.33	0.23	0.52	0.52	0.46

4. CONCLUDING REMARK

The analysis carried out in this paper aimed to provide estimates of technical efficiency in the agricultural sector in a group of Mediterranean countries involved in the process of global market liberalization. The study

[1] A recent study conducted by (Raghbendra, Nagarajan and Prasanna, 2005) in southern India, showed that land fragmentation has a significant negative impact on production efficiency.

employs a two-step approach which combines cross-sectional and panel data to assess the main factors contributing to technical inefficiencies and to explain efficiency differentials among Mediterranean countries. The analysis is carried on six different crop groups, namely fruits, citrus, shell fruits, vegetables, cereals and pulses using a panel data set covering the period 1990-2005 in fourteen Mediterranean Countries.

First, we estimated a translog production function using a fixed effects model. The results arising from this analysis show that land, water and labor are the main factors contributing to the expansion of agricultural production in Mediterranean countries. Citrus and vegetables appear to be highly sensitive to water. Capital is an important factor in the production of fruits and shell fruits production. Cereals and pulses production seem to depend mainly on cropland.

Technical efficiency indexes are measured from the comparison of the individual effects. We have attempted to account for the heterogeneity of countries by computing adjusted indicators. The study revealed the presence of important inefficiencies in Mediterranean agricultural production. Algeria, Morocco, Tunisia, Jordan and Portugal appear as enduring substantial inefficiencies in their farming operations, the mean technical efficiency is estimated to range between 35% and 50% in these countries. Greece, Lebanon, Israel, Egypt and Syria seem to be operating at a middle efficiency level varying between 50% and 70% while Turkey, France, Spain and Italy appear as the most efficient countries in the selected panel with efficiency indexes higher than 74%. Determinants of efficiency, precipitations, irrigation, mechanisation and land size have a positive impact on the efficient use of resources, while water availability and land fragmentation contribute to sub-optimal factors use.

The present study enables us to shed light on the Mediterranean countries' agricultural performances and therefore on their potential to compete with European Union Mediterranean countries. It is important to underline that without trying to quantify the effects of trade openness, which would require a deep investigation of the economic situation of the concerned countries, our analysis attempts to give some indications permitting to distinguish the ability for these countries to face the challenges resulting from a free trade policy. It appears from the analysis that with the fierce competition arising from agricultural liberalization, several South Mediterranean countries may experience some difficulties. Countries like Jordan, Tunisia, and Algeria and to a lesser extent Lebanon and Israel, suffer from limited resources for agricultural production, mainly water and land that prevent them from competing with other Mediterranean countries producing similar products such as Turkey, Spain and Italy. A solution to increase the scope of their production without raising their resource use, to narrow the existing gap with their competitors, lies with promoting efficiency. The analysis shows that these countries can enhance their outputs in some sectors, essentially citrus, vegetables and cereals, up to 50% without a substantial increase of their inputs.

Despite the moderate efficiency levels in the farming productions in Morocco, Egypt, Portugal, Greece and Syria, these countries remain exposed to smaller risks as these countries enjoy greater production capacities with their wider agricultural areas and greater water resources availability.

With the reduction of barriers in the international trade of agricultural products, competition is expected to be tougher and several SMC may loose the comparative advantage they enjoyed from the preferential concessions they were granted by the EU. In order to be able to compete in this new environment, these countries should improve their competitiveness by expanding their agricultural productions and reducing their costs. This may be achieved through enhancing agricultural efficiency and factors productivity. In line with the findings of the study, one way to attain such an objective would be to expand their irrigated areas, to ensure the modernisation of their agricultural sector by encouraging the mechanisation of the farmers and to fight against land fragmentation through re-parcelling actions.

While this study helped to characterize the current situation in some Mediterranean countries in term of efficiency, considering the different countries involved in the analysis as operating under a common technology may drag a certain imprecision on the results, since some Mediterranean countries may not have the capacity to operate on the same frontier production function as the more advanced ones. Specific regional studies including infrastructure considerations are needed to investigate the differences in productivity and technological adoption. Furthermore, government policies such as subsidization may have an impact on the performance of production units. An interesting extension of this work would be to investigate the productive efficiencies in the Mediterranean agricultural sectors considering regional technological differences. In this light, the stochastic production frontier finite mixture models and the metafrontier method including policy variables would be more appropriate approaches to explain technical efficiency differentials.

APPENDIX

Table A1: Summary statistics by country

Production	Fruits		Citrus		Shell Fruits		Vegetables		Cereals		Pulses	
1000 Mt	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev
Algeria	1129	223	418	94	28	7	2779	526	2490	1297	46	13
Spain	12473	2633	5305	537	271	51	10030	527	17992	3608	335	133
France	10644	1006	28	3	10	2	7933	641	58823	5401	2746	705
Greece	4692	450	1216	135	66	9	3923	260	4793	396	43	4
Italy	16917	1366	2985	381	218	21	10495	825	19572	1369	154	43
Portugal	1785	293	278	51	17	7	2429	158	1333	154	30	9
Israel	367	41	811	275	28	3	1338	274	255	70	11	3
Jordan	347	360	146	30	2	1	663	94	91	35	6	2
Lebanon	617	111	352	54	32	7	844	119	107	28	25	11
Morocco	1424	153	1249	173	94	24	2923	577	5576	2750	235	93
Syria	1465	259	589	151	120	56	1586	405	4993	1199	222	68
Tunisia	1262	416	266	33	47	11	1596	323	1618	697	77	19
Turkey	8516	627	2005	378	631	99	19699	2654	30131	2080	1691	233
Egypt	2925	805	2399	280	123	69	10501	2808	16835	2764	488	53

Cropland	Fruits		Citrus		Shell Fruits		Vegetables		Cereals		Pulses	
1000 ha	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev	Mean	S. Dev
Algeria	453	74	44	7	31	9	197	18	2374	837	85	17
Spain	3508	363	272	23	648	28	315	70	6195	427	464	140
France	1040	36	2	0	4	0	211	14	8422	334	580	115
Greece	965	22	66	28	45	9	119	5	1265	72	27	3
Italy	2273	62	177	4	169	13	319	17	3984	164	97	27
Portugal	733	23	27	1	41	2	159	177	461	79	53	17
Israel	37	6	27	5	6	0	36	4	92	12	7	1
Jordan	69	10	7	1	0	0	18	2	73	34	7	3
Lebanon	96	2	15	2	7	2	30	4	46	13	14	5
Morocco	639	72	76	2	148	14	117	9	5265	509	397	52
Syria	592	41	26	2	38	7	82	12	3369	316	260	38
Tunisia	1578	121	23	3	237	55	100	9	1195	419	111	25
Turkey	1438	29	84	8	416	25	797	477	13582	185	1771	246
Egypt	199	40	135	7	45	18	370	50	2478	156	172	16

Source: FAOSTAT.

Table A2: Countries characteristics

	Water Res.[1]	Agr.[2]	Machines[3]	Rain[4]	Irrigation[5]	Soil[6]	Fragmentation[7]
Algeria	14.3	39.5	1.2	211.5	1.4%	21.0%	48.0%
Spain	111.5	30.1	7.2	321.7	12.0%	38.0%	42.0%
France	203.7	30.0	5.7	478.0	8.3%	9.0%	17.0%
Greece	74.3	8.9	8.4	86.1	15.5%	48.0%	48.0%
Italy	191.3	15.7	18.2	250.8	17.3%	28.0%	56.0%
Portugal	68.7	3.9	7.3	78.6	16.6%	21.0%	49.0%
Israel	1.7	0.6	7.4	9.2	33.9%	6.0%	58.0%
Jordan	0.9	1.2	2.3	9.9	6.2%	31.0%	56.0%
Lebanon	4.4	0.3	2.9	6.9	30.5%	25.0%	53.0%
Morocco	29.0	30.6	0.5	154.7	4.3%	14.0%	71.0%
Syria	26.3	13.7	1.8	46.7	8.0%	60.0%	43.0%
Tunisia	4.6	9.4	1.1	33.9	4.0%	79.0%	53.0%
Turkey	229.3	39.5	3.3	459.5	11.3%	89.0%	39.0%
Egypt	58.3	3.2	2.9	51.4	99.7%	9.0%	45.0%

Source: FAOSTAT and World Bank databases.

1 Water Resources in km^3.
2 Total Agricultural area in Million Ha.
3 Agricultural machinery per 100 hectares of arable land.
4 Average precipitation (1961-1990) in km^3/year.
5 Part of Irrigated Area in %.
6 Part of agricultural area incurring severe and very severe degradation in %.
7 Part of exploitations having an area under five hectares in %.

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L'EFFICACITÉ TECHNIQUE DANS LE SECTEUR AGRICOLE DES PAYS MÉDITERRANÉENS

Résumé – *Ce travail cherche à évaluer les sources d'inefficacité dans le secteur agricole pour quatorze pays méditerranéens et à révéler leur potentiel pour profiter des opportunités offertes par les politiques de libre-échange. L'analyse applique le modèle des frontières de production stochastiques à un ensemble de six produits agricoles différents. Le modèle utilise les données de panel couvrant la période 1990-2005. Les résultats empiriques révèlent une grande diversité et la présence d'importantes inefficacités dans la production agricole méditerranéenne. Les pays de l'Union européenne paraissent en moyenne plus efficients que ceux du Sud de la Méditerranée, parmi lesquels certains pays tels que l'Algérie, le Maroc, la Tunisie et la Jordanie présentent de sérieuses inefficacités dans l'utilisation des ressources. Le processus d'ouverture commerciale devrait être accompagné par un programme de coopération entre les pays développés et en voie de développement, impliqués dans les accords d'association, afin de restructurer les secteurs agricoles des régions affectées par un problème de précarité des ressources et de les aider à survivre à la transition vers le libre-échange. Les résultats indiquent qu'il est possible d'accroître la production agricole dans certaines régions jusqu'à 50 % à travers l'extension des périmètres irrigués, l'encouragement à la mécanisation et la lutte contre la fragmentation des terres.*

LA EFICACIA TÉCNICA EN EL SECTOR AGRÍCOLA DE LOS PAÍSES MEDITERRÁNEOS

Resumen – *Este trabajo intenta evaluar las fuentes de ineficacia en el sector agrícola para catorce países mediterráneos y revelar su potencial para aprovecharse de las oportunidades ofrecidas por las políticas de libre comercio. El análisis aplica el modelo de las fronteras de producción estocásticas en un conjunto de seis productos agrícolas diferentes. El modelo utiliza los datos de grupo de expertos que abarcan el período 1990-2005. Los resultados empíricos revelan una gran diversidad y la presencia de importantes ineficacias en la producción agrícola mediterránea. Los países de la Unión*

Europea parecen en general más eficientes que los del Sur del Mediterráneo, entre las cuales algunos países como Argelia, Marruecos, Túnez y Jordania presentan serias ineficacias en la utilización de los recursos. El proceso de apertura comercial debería ser acompañado por un programa de cooperación entre los países desarrollados y los que son en vías de desarrollo, implicados en los acuerdos de asociación, con el fin de reestructurar los sectores agrícolas de las regiones afectadas por un problema de precariedad de los recursos y ayudarles a sobrevivir a la transición hacia el libre comercio. Los resultados indican que es posible aumentar la producción agrícola en algunas regiones hasta un 50% a través de la extensión de los perímetros irrigados, el estímulo a la mecanización y a la lucha contra la fragmentación de las tierras.