Agricultural Productivity Growth in the Euro-Med Region: Is there Evidence of Convergence?

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Abstract— **This paper measures agricultural productivity growth by means of the sequential Malmquist Total Factor Productivity (TFP) index among a set of thirty-two countries including West European, Central and East European (CEE) and Middle East and North African (MENA) countries for the period 1961-2002. At a second stage it is also investigated whether this measure is converging among the countries, by employing cross-sectional tests for absolute and conditional β-convergence as well as for club convergence. Results suggest that despite the fact that the CEE and MENA countries exhibit a high rate of productivity growth after the 1990s, absolute convergence cannot be accepted. Still, evidence for conditional convergence is found and the formation of two separate clubs of countries that converge to different equilibrium points is identified.**

Keywords— **Productivity growth, sequential Malmquist TFP, convergence.**

I. Introduction

The issue of productivity growth has drawn considerable attention over the last few decades, as it is considered the major source of development for the agricultural sector, at a rate able to meet the demands for food and raw materials arising out of steady population growth. A country that falls short of achieving agricultural productivity growth may suffer a deterioration, either of the foreign exchange balance, or of the internal terms of trade against industry, thereby also hindering industrial production ([1] and [2]). In contrast, a country that best utilises its given resources within its agricultural sector may enjoy a significant comparative advantage in exporting markets.

At the same time, the neoclassical growth theory suggests that the existence of decreasing returns and exogenous technological change generates in the long run a common convergence path even for economies with unequal initial states, thereby predicting that countries with relatively low initial levels of productivity will grow relatively faster and 'catch up' with the high productivity ones [3]. On the other hand, the endogenous growth theory accepts structural differences across countries by treating technological change as endogenous, thereby allowing for permanent differences in productivity growth levels [4]. This contradiction has triggered increased attention, making the testing of the convergence hypothesis a major issue in economic research over the last decades [5].

Within this conceptual framework, the objective of this paper is twofold: Firstly, to analyse agricultural productivity growth in European and Middle East and North African[1] (MENA) countries by means of Malmquist Total Factor Productivity (TFP) indices and secondly, to investigate whether TFP is converging across the sampled countries.

The recent enlargement of the EU – now comprised of 27 Member States - has created the world's largest market for agricultural and food products. Considering also the Euro-Mediterranean Partnership (i.e. Barcelona Agreement) between the EU and the Mediterranean countries aiming at the creation of a Free Trade Zone around the Mediterranean basin, then a vast market with potentially barrier-free trade for agricultural products is generated. Agricultural productivity in Europe as well as in MENA has

[1] Only the MENA countries that are situated around the Mediterranean basin are selected in this study.

exhibited considerable growth over the last four decades, especially during the Green Revolution era (late 1960s to early 1980s). In this sense, it is interesting to examine its sources in each country and compare the growth patterns across this region, given that differences in agricultural productivity levels and growth rates may help identify underlying factors that affect - positively or negatively – productivity growth [6].

The sample is comprised of thirty-two countries, among which natural conditions and resources may vary significantly (i.e. land size, salinity and solidity, water availability, mechanisation, etc.), thereby forming a rather heterogeneous group of countries with different institutional and development levels. Still, within this group, certain subsets (or clubs) can be identified, comprised of countries that exhibit more common characteristics; the EU-15 Member States, the former Central and East European Countries (CEEC) and the MENA countries. In CEEC and MENA countries, agriculture is a vital component of their national economies, expressed in terms of share of Gross Domestic Product (GDP), exports and employment. Particularly the Mediterranean countries (both south European and MENA) are traditional exporters of agricultural products. Even the non-EU countries have bilateral and/or multilateral preferential trade agreements with the EU (i.e. Euro-Mediterranean Partnership), whilst their agricultural sectors are undergoing serious structural changes (following the overall liberalising of their economies), as a means of meeting both EU qualifications, as well as WTO agreement provisions. This argument holds also for the CEEC group: agriculture in these countries is undergoing a transitional phase, following the overall restructuring of their economy that commenced in the early 90s. Land reform and the dismissal of the centrally planned system is a major characteristic in all ex-Communist countries.

The remainder of the paper is organised as follows: The next section briefly discusses some key methodological aspects by reviewing basic approaches applied in the relevant literature and defines the empirical framework of this study. Results are presented and discussed in the subsequent section, and some concluding comments are made in the final section.

II. Theoretical background and empirical framework

A. TFP growth

DEA models are linear programming (LP) methods that calculate the frontier production function of the decision-making units (firms or countries) included in the sample. Those that operate on the frontier are technically efficient, whereas the degree of technical inefficiency of the rest is calculated on the basis of the Euclidian distance of their input/output ratio from the frontier. A DEA-based, output-oriented Malmquist productivity change index (in time *t+1* and *t*) was developed by Färe *et al.*[7] and can be defined as follows:

$$M\left(y_{t+1}, x_{t+1}, y_t, x\right) = \underbrace{\left[\frac{D^{t+1}\left(x_{t+1}, y_{t+1}\right)}{D^{t}\left(x_t, y_t\right)}\right]}_{TECh} \times \underbrace{\left[\frac{D^{t}\left(x_{t+1}, y_{t+1}\right)}{D^{t+1}\left(x_{t+1}, y_{t+1}\right)} \frac{D^{t}\left(x_t, y_t\right)}{D^{t+1}\left(x_t, y_t\right)}\right]^{1/2}}_{TNCh} \quad (1)$$

where x_t is an input vector and y_t is an output vector for country *i* used in period *t*. Hence, this index measures the productivity of a country at the production (x_{t+1}, y_{t+1}) relative to (x_t, y_t) and is the geometric mean of two (consecutive) Malmquist TFP indices, one using technology of period *t* and the other using technology of period *t+1*. Productivity may decline if the obtained value is less than one, remain unchanged if equal to one and improve if greater than one. In (1), the first component measures the change in technical efficiency change (TECh) and the second measures the technical change (TNCh), i.e. the technology frontier shift between the two time periods.

Unlike the contemporaneous Malmquist TFP where the frontier in each period is constructed based on the observations solely of the current year, the sequential TFP, in the manner of Tulkens and Vanden Eeckaut [8], accumulates and envelops all data until the present year. In other words, the fundamental difference among the two methods is the way the frontier is constructed and how technology is considered. The contemporaneous Malmquist index in any time t does not depend on data of the previous period and therefore the frontier may move towards, or away from the origin between two consecutive time periods, indicating technological regress or progress respectively. In contrast, the sequential Malmquist index, by enveloping all past observations, assumes that any technology available in the preceding periods is also available in the present, i.e. technical knowledge accumulates over time. Therefore, technological regress is not possible under the sequential frontier [9]. Dealing with agricultural productivity in particular, there is no apparent reason to assume that the technology used in a previous period in agriculture will become infeasible in the next years; hence technological regression in the agricultural sector is possible but not very likely. In addition, it is more reasonable to interpret any adverse effects of weather for instance, as deterioration in technical efficiency rather than technology regress, which is the case under the sequential Malmquist index procedure [10]. Ultimately, the sequential approach generates a more stable frontier and is less sensitive to the presence or not of a particular observation in the sample, making the results generally more trustworthy, especially in cases where the number of observations in the cross-section sample are small relative to the total number of variables (inputs and outputs) used ([10] and [9]).

B. Tests of convergence

The convergence hypothesis assumes that productivity growth rates (defined as TFP) are likely to be inversely related to the initial level of productivity[2]. This is the notion that rests behind the cross-section methods of testing convergence, pioneered by Barro and Sala-i-Martin [11], which are used to test for β- convergence as well as for σ-convergence. The former holds if the coefficient of a regression of TFP growth rates on initial TFP levels is negative whilst the latter if the dispersion of the log of TFP, measured by its standard deviation decreases over time [12].

Alternative approaches for testing convergence were introduced by Bernard and Durlauf [13] that exploit the time variation of productivity levels. Such time-series tests (termed stochastic convergence) accept convergence if the long run forecasts of productivity differences tend towards zero and their concept is related to the unit root hypothesis[3]. One limitation of time-series tests is that they are more appropriate when sampled economies are near their steady state equilibrium; if economies are in transition, moving towards a steady state, cross-section tests are preferable [3]. Given that the sample in this study is comprised of countries with different levels of development and most can be identified as being in a transitional phase (MENA and CEEC), cross-sectional tests of convergence are used.

To test for absolute (unconditional) β- convergence, the following equation is employed:

$$(1/T)(y_{iT} - y_{i0}) = a + \beta y_{i0} + u_{i0,T} \qquad (2)$$

where y_{iT} and y_{i0} are the log of TFP for country i in the final and the initial year of observation, respectively and $u_{i0,T}$ is an error term with mean zero. The convergence hypothesis is accepted if β is significantly negative; otherwise divergence is accepted.

Absence of unconditional convergence as defined in (2) could be attributed to cross-country differences in the constant variable. In order to account for these differences, the above equation can be expanded so as to include a set of additional explanatory variables in the right-hand-side that account for coefficient heterogeneity and determine the individual steady-state of the countries. In this case, conditional convergence is implied, as it refers to countries with the same initial levels of these additional variables [12].

[2] The convergence theory of neoclassical models was initially introduced as a concept of *per capita income* convergence, rather than *productivity growth* convergence. In the context of this paper, these different concepts are affiliated for simplicity reasons.

[3] Bernard and Durlauf [13] actually refer to per capita output convergence – see footnote 2. For a more elaborate discussion on time-series tests of convergence, see [5].

The transitional growth process that is used for testing for β- convergence as defined above, explicitly assumes that all economies tend to converge either to the same steady-state (absolute, or unconditional convergence), or to their own steady-state (conditional, or weak convergence). However, it is possible that within a set of countries – especially when comprised of economies with large degrees of heterogeneity - certain countries might tend to converge to a particular steady-state among themselves, thereby forming a convergence club and diverge from countries that form other group(s). In such a case, convergence may happen *within* each group but not *across* different groups [14]. This notion, often referred to as club convergence, was originally investigated by Baumol and Wolff [15] and extended by Chatterji [16] and Chatterji and Dewhurst [17], who propose a procedure in which (2) is reformulated by including the gap variable, i.e. the log of the difference of the key variable between the leading country and any other country in the group. In this paper, we apply a slight modification of this procedure, by realizing a leading *group* rather than *country*, as in (3):

$$\ln\left[\frac{y_{AT}}{y_{A0}}\right]-\ln\left[\frac{y_{iT}}{y_{io}}\right]\Rightarrow\ln\left[\frac{y_{AT}}{y_{iT}}\right]=\ln\left[\frac{y_{A0}}{y_{i0}}\right]+\beta\ln\left[\frac{y_{A0}}{y_{i0}}\right]+u_{io,T} \quad (3)$$

where the subscript *A* stands for the EU-6 TFP average, and *i* for that of any other country in the group. By re-arranging, we get:

$$\ln\left[\frac{y_{AT}}{y_{iT}}\right]=(1+\beta)\ln\left[\frac{y_{A0}}{y_{i0}}\right]+u_{io,T} \quad \text{or,}$$

$$\ln\left[\frac{y_{AT}}{y_{iT}}\right]=\gamma\ln\left[\frac{y_{A0}}{y_{i0}}\right]+u_{io,T} \quad (4)$$

where $\gamma = 1+\beta$. It is possible to generate two or more groups of countries (clubs), by introducing in (4) further powers of the gap (i.e. log (y_A) – log (y_i), denoted by *G*) in period 0, thus deriving to:

$$G_i^T=\sum_{k=1}^{K}\gamma_k\left(G_i^0\right)^k+u_{io,T} \quad (5)$$

The number of clubs and multiple equilibria will depend upon the values attributed to *k*. If *k*=3, we end up with a cubic polynomial equation, where there is a possibility of three equilibria and two convergence clubs depending upon the value of the parameters γ_1, γ_2 and γ_3. If $\gamma_1 < 1$ and $\gamma_2 = \gamma_3 = 0$, strong convergence to the leader (country) for all the countries is indicated. If the three parameters are non-zero, there can be two alternative situations: (i) $\gamma_1 < 1$, by which the resolution of (5) leads to the determination of three equilibria, two being stable and the other unstable, and (ii) $\gamma_1 > 1$, by which there is only one stable equilibrium [16].

III. DATA AND RESULTS

A. Productivity growth –Malmquist TFP indices

The model constructed was comprised of one output and five inputs, involving a set of thirty-two countries; sixteen West European countries (EU-15 and Malta and Norway)[4], five CEEC (Albania, Bulgaria, Hungary, Poland and Romania) and eleven MENA (Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia and Turkey). The period under investigation was 1961-2002, while all required data were taken from the Food and Agriculture Organisation (FAO) database. More specifically, the variables are defined as follows: Value of agricultural produce (y); Land (x_1); Labour (x_2); Fertilisers (x_3); Machinery (x_4); Livestock capital (x_5)[5]. Unambiguously, these FAO data have certain shortcomings, acknowledged by other researchers that have also used them (see for instance [6] and [18]) but they are still the most comprehensive data source available for such studies [2]. It should be stressed that although the dataset begins in 1961, the starting year for efficiency calculations is 1965. Data from 1961 to 1965 were pooled so as to reach 160 observations in the initial year and overcome problems generated by

4 Belgium and Luxembourg are considered as one economy denoted "Bel-Lux".

5 For all variables, the respective definitions of FAO have been used, except (x_5) which corresponds to the number of animals in cows equivalent, as expressed in [1].

the large number of variables compared to the number of countries included.

Table 1 summarises the main findings of the empirical analysis regarding Malmquist indices and productivity growth rates. Average technical efficiency in the base period is 0.825, although there are four countries that exhibit a large degree of technical inefficiency, more than 50% (i.e. Libya, Tunisia, Albania and Algeria). By contrast, ten countries (Austria, Bel-Lux, Denmark, Egypt, Israel, Italy, Netherlands, Poland, Sweden and UK) are fully technical efficient. It is interesting to note that the EU-6 countries are nearly fully technical efficient (99%), whereas the CEEC group exhibit a technical efficiency of 78% and the

Table 1: Decomposition of agricultural TFP growth rates

		1966-2002			1966-1979			1980-1989			1990-2002		
	TE*	TECh	TNCh	TFP	TECh	TNCh	TFP	TECh	TNCh	TFP	TECh	TNCh	TFP
Albania	0.436	1.000	1.006	1.006	0.981	1.005	0.985	0.995	1.011	1.006	1.024	1.003	1.027
Algeria	0.463	0.983	1.002	0.985	0.938	1.002	0.940	1.006	1.002	1.008	1.015	1.002	1.017
Austria	1.000	1.002	1.003	1.006	1.005	1.002	1.007	1.002	1.003	1.005	1.000	1.005	1.005
Bel-Lux	1.000	1.000	1.001	1.001	1.000	1.001	1.001	1.000	1.001	1.001	1.000	1.001	1.001
Bulgaria	0.744	1.006	1.022	1.028	1.010	1.020	1.030	0.997	1.033	1.029	1.010	1.016	1.026
Cyprus	0.922	0.989	1.013	1.002	1.000	1.008	1.008	0.993	1.009	1.002	0.975	1.021	0.995
Denmark	1.000	1.000	1.014	1.014	0.985	1.016	1.000	1.021	1.014	1.035	1.001	1.013	1.014
Egypt	1.000	1.000	1.002	1.002	1.000	1.001	1.001	1.000	1.000	1.000	1.000	1.005	1.005
Finland	0.934	1.000	1.008	1.007	0.993	1.009	1.002	1.010	1.001	1.011	0.999	1.011	1.010
France	0.962	1.000	1.007	1.007	1.000	1.006	1.006	1.000	1.006	1.006	1.000	1.009	1.009
Germany	0.976	1.002	1.005	1.007	1.002	1.005	1.007	1.003	1.003	1.007	1.000	1.006	1.006
Greece	0.815	1.005	1.007	1.012	0.999	1.009	1.008	1.024	1.005	1.029	0.996	1.006	1.002
Hungary	0.941	1.004	1.007	1.011	1.013	1.008	1.021	1.000	1.008	1.008	0.998	1.004	1.002
Ireland	0.900	1.000	1.004	1.004	1.000	1.002	1.002	1.000	1.006	1.006	0.999	1.005	1.004
Israel	1.000	1.000	1.005	1.005	1.000	1.004	1.004	1.000	1.002	1.002	1.000	1.007	1.007
Italy	1.000	0.999	1.008	1.007	1.000	1.005	1.005	0.997	1.006	1.003	1.000	1.012	1.012
Jordan	0.716	0.991	1.012	1.002	0.938	1.009	0.946	1.025	1.014	1.039	1.024	1.013	1.037
Lebanon	0.950	0.999	1.008	1.007	1.000	1.012	1.012	1.000	1.010	1.010	0.996	1.002	0.998
Libya	0.272	1.001	1.017	1.017	0.978	1.007	0.985	1.014	1.024	1.039	1.015	1.022	1.037
Malta	0.967	1.000	1.001	1.001	0.996	1.000	0.996	1.005	1.001	1.007	1.000	1.002	1.002
Morocco	0.553	0.984	1.003	0.987	0.947	1.000	0.947	1.026	1.005	1.032	0.992	1.006	0.997
Nether.	1.000	1.000	1.003	1.003	1.000	1.004	1.004	1.000	1.003	1.003	1.000	1.003	1.003
Norway	0.789	0.996	1.009	1.005	1.001	1.010	1.011	1.004	1.002	1.006	0.985	1.012	0.997
Poland	1.000	1.001	1.004	1.005	1.002	1.002	1.004	1.000	1.005	1.005	1.000	1.006	1.006
Portugal	0.774	0.983	1.009	0.992	0.959	1.010	0.968	0.993	1.004	0.997	1.002	1.012	1.014
Romania	0.766	0.994	1.008	1.001	0.969	1.005	0.974	0.977	1.011	0.988	1.035	1.007	1.042
Spain	0.881	0.998	1.012	1.010	0.999	1.014	1.012	0.993	1.005	0.998	1.002	1.015	1.016
Sweden	1.000	0.996	1.007	1.004	0.998	1.005	1.002	1.002	1.005	1.006	0.990	1.013	1.003
Syria	0.604	0.999	1.008	1.006	0.978	1.009	0.987	0.978	1.008	0.986	1.038	1.006	1.044
Tunisia	0.409	0.989	1.007	0.996	0.988	1.002	0.990	0.984	1.009	0.994	0.993	1.012	1.004
Turkey	0.629	1.000	1.008	1.008	0.990	1.002	0.992	0.997	1.008	1.005	1.015	1.013	1.029
UK	1.000	0.994	1.017	1.012	0.988	1.026	1.013	1.004	1.009	1.013	0.994	1.015	1.009
Average**	0.825	0.997	1.008	1.005	0.989	1.007	0.996	1.002	1.007	1.009	1.003	1.009	1.012
EU-6	0.987	1.000	1.005	1.005	1.000	1.004	1.004	1.000	1.004	1.004	1.000	1.006	1.006
CEEC	0.777	1.001	1.009	1.010	0.995	1.008	1.003	0.994	1.013	1.007	1.013	1.007	1.021
MENA	0.683	0.994	1.008	1.002	0.978	1.005	0.983	1.002	1.008	1.010	1.006	1.010	1.015
W. Europe	0.937	0.998	1.007	1.006	0.995	1.008	1.003	1.004	1.005	1.008	0.998	1.009	1.007

* TE refers to the base period (1961-65)

** Average TE is arithmetic mean, whereas average TECh, TNCh and TFP are geometric means

MENA countries a much lesser 69%, notably due to the three countries (Libya, Tunisia and Algeria) that are exceptionally inefficient.

In the whole period 1966-2002, the sampled countries show on average an annual 0.27% deterioration in the technical efficiency of their agricultural sectors. Bulgaria, Greece and Hungary exhibit the highest technical efficiency gains (0.6%, 0.5% and 0.4% respectively). The CEEC is the only group that exhibits even a minor (0.1%) positive technical efficiency change, whereas the MENA countries show the largest deterioration rate (0.6%).

Given that the sequential TFP does not allow for technological regression, it is evident that the distinction is made only on the grounds of progression and stagnation: Seven countries, namely Bulgaria, Libya, UK, Denmark, Cyprus, Jordan and Spain exhibit the highest technological changes (more than 1% and up to 2.2% for the first country) whereas another seven countries (Algeria, Austria, Bel-Lux, Egypt, Malta, Morocco and the Netherlands) are more or less stagnant (with an annual growth rate of TNCh no more than 0.3%). Both the CEEC as well as the MENA group exhibit a higher technical change than the EU-6 and the West Europe group.

The evolution of TFP changes in the period under study shows that on average, there is a 0.5% agricultural productivity growth in the region. Bulgaria (2.8%), followed by Libya, Denmark, Greece, UK and Spain - all above 1% annual increases - are the leading countries in productivity growth rates. All the remaining countries, with the exception of Algeria, Morocco, Portugal and Tunisia exhibit positive productivity changes, ranging from 0.1 to 0.8% per annum. Algeria in fact, exhibits high TFP growth rates in the last two periods, being well above the average in the last one, but its growth rates were negative prior to 1980. With the exception of Morocco, the same holds for the rest of these countries; in the latter period they exhibit positive TFP growth rates. CEEC exhibit a productivity growth rate that is twice as high as the EU-6, whereas the MENA countries' growth rate is less than half of the EU-6.

Turning to the next columns of Table 1, the evolution of TFP and its components are broken down into different time periods so as to highlight differences in growth patterns. In the first period 1966-79, TECh and TFP changes are both negative (-1.1 and -0.4% respectively), although there are significant technological improvements (0.7%). During this period, the EU-6 group exhibits the highest productivity growth rate. In the following two periods however, TFP growth for EU-6 remained relatively stable, while for the other groups it increased at a significant rate; For the CEEC it increased from 0.3 to 0.7 in the 80s and to 2.1% in the last period and for the MENA group it changed from negative in the 70s to positive thereafter (1 and 1.5% in the two periods respectively). Consequently, it can be argued that the countries with lower initial ----levels of productivity (CEEC and MENA) show higher growth rates in the last years. This could be sustained by the fact that in the last period there are four countries that belong to these groups (Syria, Romania, Libya and Jordan) that attain a TFP growth ranging from 3.7% to as much as 4.4%. Ultimately though, it is evident that these higher growth rates in the latter periods are not sufficient to bridge the gap between them and the EU countries.

B. Convergence of TFP

Estimates of the unconditional β- convergence were obtained by estimating (2). Results are reported in Table 2, which shows that for the entire period 1966-2002 convergence of agricultural TFP across the Mediterranean countries cannot be accepted; the β-coefficient is negative (indicating convergence), but insignificant. Still, by breaking down the full period into three sub-periods, 1966-1979, 1980-1989 and 1990-2002, it is possible to highlight some noticeable differences: during the first two sub-periods, the β-coefficient is insignificant in both cases, but still it has a positive sign in the first and a negative in the second period. In contrast, during the last period (1990-2002) the β- coefficient has the desired sign and is statistically significant. Hence, absolute convergence in the latter period cannot be rejected. This finding can be related to the ones mentioned in the previous section, where productivity growth for the less developed country groups was found to be increasing after 1990.

In other words, results suggest that although agricultural productivity does not appear to exhibit signs of absolute convergence across the European and the Mediterranean countries in the period 1966-2002, divergence was more obvious until the 1980s (i.e. during the Green Revolution era). Evidence from the plot of cross-sectional standard deviations of TFP growth rates (Figure 1) further sustains the above

Table 2: Cross-section estimates of absolute and conditional β - convergence in agricultural TFP

	1966-2002		1966-1979		1980-1989		1990-2002	
	Absolute	Conditional	Absolute	Conditional	Absolute	Conditional	Absolute	Conditional
	0.0061	0.0059	0.0038	0.0056	0.0059	0.0061	0.0086	0.0073
Constant	*(4.46)*	*(4.1)*	*(1.19)*	*(1.52)*	*(2.58)*	*(2.07)*	*(4.16)*	*(2.72)*
	[0.00]	*[0.00]*	*[0.24]*	*[0.14]*	*[0.02]*	*[0.05]*	*[0.00]*	*[0.01]*
	-0.0007	-0.0175	0.008	-0.016	-0.0041	-0.0142	-0.0092	-0.0184
β-coeff.	*(-0.26)*	*(-3.03)*	*(1.27)*	*(-1.07)*	*(-1.05)*	*(-1.80)*	*(-2.41)*	*(-2.85)*
	[0.80]	*[0.01]*	*[0.21]*	*[0.29]*	*[0.30]*	*[0.08]*	*[0.02]*	*[0.01]*
		0.0093		0.0145		0.0079		0.0072
MENA		*(2.31)*		*(1.39)*		*(0.91)*		*(1.02)*
		[0.03]		*[0.18]*		*[0.37]*		*[0.32]*
		0.0021		-0.0099		0.0056		0.0091
CEEC		*(0.75)*		*(-1.35)*		*(0.92)*		*(1.68)*
		[0.46]		*[0.19]*		*[0.37]*		*[0.11]*
		-0.0004		-0.0006		-0.0004		-0.0005
ILLIT		*(-3.68)*		*(-2.13)*		*(-1.56)*		*(-1.81)*
		[0.00]		*[0.04]*		*[0.13]*		*[0.08]*
		0.0002		0.0002		0.0001		0.0001
IRRIG		*(1.84)*		*(1.07)*		*(0.62)*		*(1.21)*
		[0.08]		*[0.3]*		*[0.54]*		*[0.24]*
R^2	0.002	0.362	0.051	0.245	0.035	0.18	0.162	0.357
F-test	0.067	2.946	1.616	1.685	1.096	1.139	5.812	2.89
	[0.80]	*[0.03]*	*[0.21]*	*[0.17]*	*[0.30]*	*[0.37]*	*[0.02]*	*[0.03]*

Notes: Figures in parentheses are t values, while those in brackets are p-values

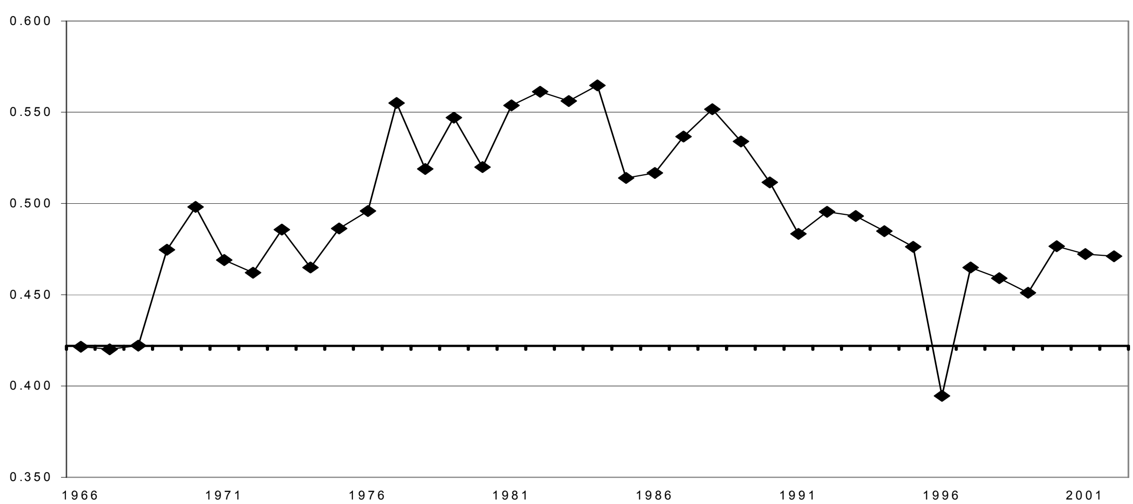


Figure 1: Standard deviation of log TFP, 1966-2002

arguments. Given that absolute β-convergence was rejected for the whole period, it is not a surprise that σ-convergence is also rejected[6]. Nonetheless, a steady

[6] β- convergence is a necessary, though not sufficient condition of σ- convergence. Still, β- convergence can be perfectly consistent with the absence of σ- convergence [5].

increase in the dispersion of the cross-sectional standard deviations of the log of TFP until 1984, and a downward tendency thereafter is evident; in 1984 the standard deviation reached 0.57 (from 0.42 in 1966), only to drop to 0.47 in 2002.

Failure to accept absolute convergence is not uncommon in the literature. In this case, the neoclassical growth theory allows for conditional β-convergence when the sampled countries exhibit significant differences in their key parameters. In order to control for such differences, (2) was extended by including an additional set of explanatory variables: Two regional dummies were introduced, taking the value of one for CEEC and MENA countries respectively. In addition, ILLIT represents the percentage of illiteracy rate among the population of each country and IRRIG represents the percentage of irrigated land to total arable land. Results reported in Table 2 show that conditional convergence in the period 1966-2002 is strongly accepted. All coefficients have the desired sign, while for MENA and ILLIT they are statistically different from zero and for IRRIG it is only marginally not significant. Finally, in the two initial sub-periods conditional convergence is rejected, but it is accepted in the last period.

It is apparent that the results from the previous methodologies are somewhat mixed. This could provide grounds for arguing that although not all countries tend to have the same steady-state, certain groups within the sample may. It is true that β-convergence may be found even when *some* but not *all* the economies within the sample are converging [19]. To test this scenario, two different regression specifications of (5) were employed, one assuming a full polynomial order as developed by Chatterji and one restricted model with some parameters equal to zero. As reported in Table 3, data fit to a cubic polynomial order, with the gap coefficient being negative and statistically significant.

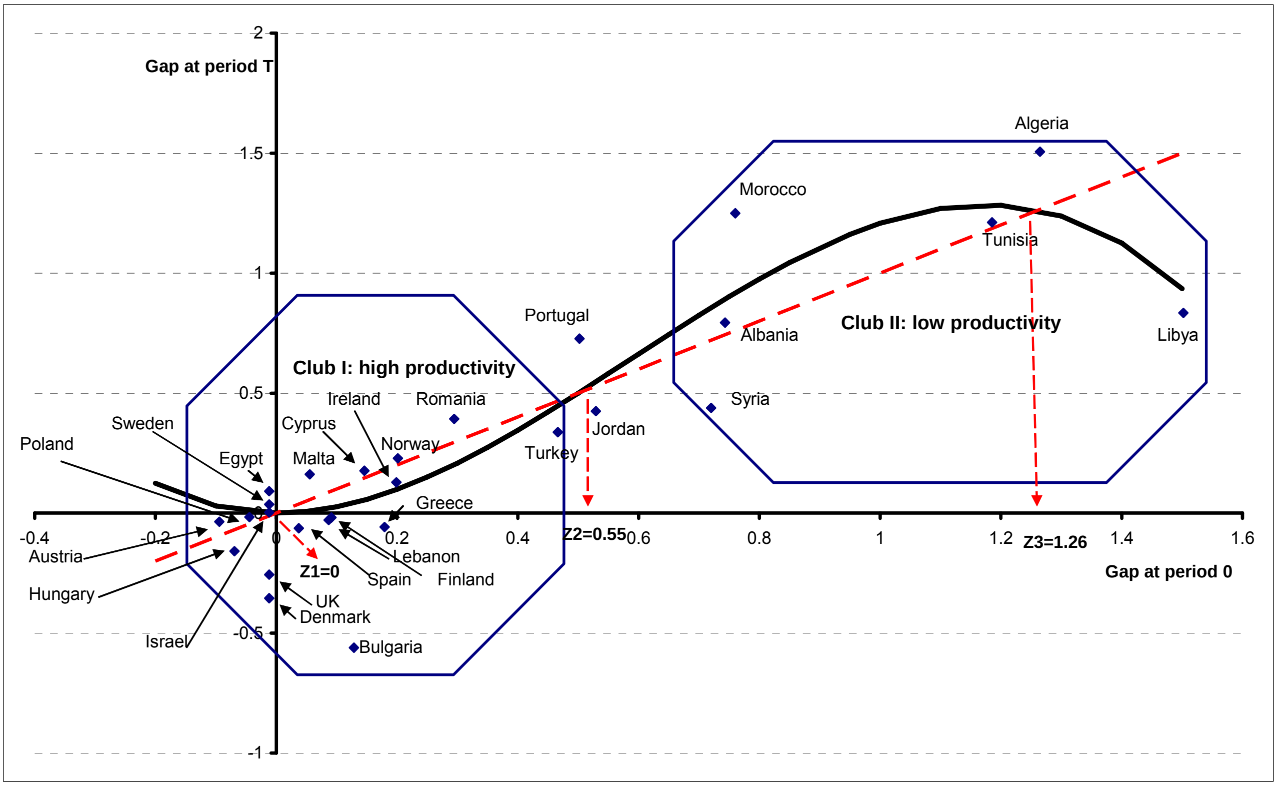
Hence, by plotting the productivity gap of each country from the EU-6 average at the final and the initial year, it can be shown that that there are three equilibrium points, thereby implying the existence of two different convergence clubs (Figure 2): Z_1 is the equilibrium point (corresponding to the origin) for the first club, comprised of those countries that converge to the EU-6 average by narrowing over time their respective gap from the leader (i.e. countries with high productivity growth rates). Z_2 is an unstable equilibrium point, given the positive slope of the curve at the point of intercept with the 45^0 line, while Z_3 is the equilibrium point for the second club, comprised of the countries that drift further apart from the EU-6 average and converge towards a level of productivity much smaller than that of the leader (i.e. countries with low productivity growth rates). These countries are Albania, Algeria, Libya, Morocco, Syria and Tunisia, i.e. all but one belonging to the MENA countries. The test is inconclusive for two countries, Portugal and Jordan, but it appears that they too would eventually converge to Z_3 in the long-run.

Table 3: Regression results on convergence clubs in the EUROMED region

Explanatory variables	Period 1966-2002	
	(1)	(2)
$\left(G_i^0\right)$	-0.112497 (-0.220) [0.825]	
$\left(G_i^0\right)^2$	3.02930 (2.668) [0.008]	2.79130 (7.879) [0.000]
$\left(G_i^0\right)^3$	-1.69600 (-2.946) [0.003]	-1.58414 (-5.933) [0.000]
R^2	0.832 [0.818]	0.833 [0.827]
F-test	10.920 [0.000]	

Notes: Two model specifications were estimated. The first one – designated by (1) – is the full polynomial specification as developed by Chatterji. The second specification – designated by (2) – is a restricted model with some parameters equal to zero.
Figures in parentheses below the estimated coefficients are t-values while those in square brackets are p-values.
The figure in square brackets under each R^2 is the adjusted R^2.
The F-test allows to test that the null hypothesis that the parameters β_l but β_l are equal to zero. The figure in square brackets under the F-statistic is p-value of the test.

Figure 2: Equilibrium points and convergence clubs



Note: Within the "High productivity club", the countries closer to the equilibrium point are, Sweden, Israel, Poland, Egypt, Austria, Spain, UK and Denmark.

IV. Conclusions

This paper has investigated the levels and growth patterns in agricultural productivity in the European and Mediterranean countries that are a part of the Euro-Mediterranean Free Trade Zone. For this purpose, the sequential Malmquist approach was employed in order to calculate TFP indices. Results show that the average growth rate of agricultural productivity reached 0.5% per annum in the period 1966-2002, largely due to a technical change increase rate of 0.8% and despite the negative technical efficiency changes (-0.3%). Although TFP grew at considerably higher rates in the later years, reaching 1.2% in the period 1990-2002 and TECh turned positive, it is suggested that a complete catching-up did not occur, given that eventually, for the whole period, the frontier shifts (i.e. TNCh) were greater than the movements towards the frontier (i.e. TECh). In general, CEEC managed to narrow the gap with the leading European countries at a much faster pace than the MENA countries.

Tests of unconditional convergence of agricultural TFP across the sampled countries failed to find evidence of diminishing disparities. The convergence hypothesis was rejected for the whole period under investigation, but evidence of convergence is provided for the final sub-period after 1990. Coelli and Rao

(2003) measuring agricultural TFP growth in a set of 93 countries worldwide, despite not testing for convergence, also note that in the period 1980-2000 there is a reversal in the tendency of a widening gap in productivity levels between high- and low-performing countries, that was recorded in the prior period.

In contrast, conditional convergence across the European and Mediterranean countries was accepted for the period 1966-2002, suggesting that countries tend to converge to their own steady state. Ultimately, the test for club convergence revealed the existence of two distinctive clusters within the sample: High productivity countries (mainly EU-15 and CEEC) tend to converge to a common level, whereas low productivity ones (mainly MENA) tend to diverge from the rest and converge to another, separate level.

A potential shortcoming of this study is that it focused solely on the convergence of TFP across the sampled countries. Because of the decomposition of TFP in technical efficiency changes and technical changes - which in this study proved to have opposite evolution over the sampled period - further research could be extended by testing separately the convergence of both TECh and TNCh. Such a research could provide additional insights to the convergence issue: are differences in terms of efficiency changes or in terms of technological adaptation the underlying reason that some countries do not manage to catch up with the rest?

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REFERENCES

1. Hayami, Y., and Ruttan, V.W. (1970). Agricultural Productivity Differences among Countries. *American Economic Review,* vol. 60(5), 895-911.
2. Coelli, T. J. and Rao, D.S.P. (2003). Total factor productivity growth in agriculture: a Malmquist index analysis of 193 countries. Centre for Efficiency and Productivity Analysis. School of Economics. University of Queensland. St Lucia. Australia. Working paper 02/2003. 30 pages
3. Freeman, D.G. and Yerger, D.B. (2001). Interpreting cross-section and time-series tests of convergence: The case of labor productivity in manufacturing. *Journal of Economics and Business*, 53, 593-607.
4. Ludena, C. E., Hertel, T. W., Preckel, P. V., Foster, K. and Nin-Pratt, A. (2005). Technological change and convergence in crops and livestock production. Contributed paper presented for the 8th Annual Conference on Global Economic Analysis, Lübeck, Germany, June 9-11, 2005.
5 Islam, N. (2003). What have we learnt from the convergence debate? *Journal of Economic Surveys*, 17(3), 309-362.
6. Wiebe, K., Soule, M., Narrod, C., and Breneman, V. (2000). Resource quality and agricultural productivity: a multi-country comparison. Selected paper for presentation at the annual meeting of the American Association of Agricultural Economists. Tampa, Florida, July 31 2000.
7. Färe, R., Grosskopf, S., Lindgren B. and Roos P. (1992). Productivity change in Swedish pharmacies 1980-1989: A non-parametric Malmquist approach. *Journal of Productivity Analysis,* 3, 85-102.
8. Tulkens, H. and Vanden Eeckaut P. (1995). Non-parametric efficiency, progress and regress measure for panel data: Methodological aspects. *European Journal of Operational Research*. Vol 80: 474-499
9. Shestalova, S. (2003). Sequential Malmquist indices of productivity growth: An application to OECD industrial activities. *Journal of Productivity Analysis*, 19, 211-226.
10. Thirtle, C., Piesse, J., Lusigi, A., and Suhariyanto, K. (2003). Multi-factor agricultural productivity, efficiency and convergence in Botswana, 1981-1996. *Journal of Development Economics*, 71, 605-624.
11. Barro, R.J and Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, 100(2), 223-251.
12. Gutierrez, L. (2000). Convergence in US and EU agriculture. *European Review of Agricultural Economics*, 27(2), 187-206.
13. Bernard, A. and Durlauf, S. (1995). Convergence in international output. *Journal of Applied Econometrics*, 10, 97-108.
14 Castro, J.V. (2004). Indicators of real economic convergence. A primer. UNU-CRIS e-Working Paper W-2004.2. United Nations University.
15. Baumol, W.J. and Wolff, E.N. (1988). Productivity growth, convergence and welfare: reply. *American Economic Review*, 78, 1155-1159.

16. Chatterji, M. (1992). Convergence clubs and endogenous growth. *Oxford Review of Economic Policy*, 8(4), 57-69.
17. Chatterji, M. and Dewhurst, J.H. (1996). Convergence clubs and relative economic performance in Great Britain: 1977-1991. *Regional Studies*, 30, 31-40.
18. Suhariyanto, K. and Thirtle, C. (2001). Asian agricultural productivity and convergence. *Journal of Agricultural Economics*, vol. 52(3), 96-110.
19. McErlean, S. and Wu, Z. (2003). Regional agricultural labour productivity convergence in China. *Food Policy*, 28, 237-252.