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Full Length Research Paper

Measuring agricultural productivity growth in MENA countries

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This paper investigates the patterns of agricultural productivity growth in 16 Middle East and North Africa (MENA) countries during the period 1970 - 2000. We use a nonparametric, output-based Malmquist index to examine whether our estimates confirm or invalidate the previous studies results indicating the decrease of agricultural productivity in developing countries. We will show that on average, agricultural productivity growth increased at an annual rate of 1% during the whole period. Our estimations show that technical change is the main source for this growth. Those results weaken as a whole the findings of the other studies, however we find a decrease in agricultural productivity mainly for developing countries suffering from political conflicts and wars. This paper fills the void of hardly any agricultural studies on MENA countries collectively, especially on productivity trends.

Key words: Agricultural productivity growth, MENA region, Malmquist productivity index.

INTRODUCTION

Agricultural productivity growth is important because it is an essential source of overall growth in an economy. That is why productivity differences among countries, and mainly between developed and underdeveloped ones, emerged as a central issue of development economics.

Aggregate productivity can be defined as the amount of output that can be obtained from given levels of input in a sector or an economy. Therefore, increases in productivity occur when output from a given level of inputs increases. This phenomenon is mainly attributed to improvements in the technical efficiency with which the inputs are used and innovations in technology that allow more output to be produced (TFP indices can capture also the effects of improved infrastructure such as irrigation, roads and electricity, as well as technology in the form of research and development.

Total factor productivity (TFP) as a measure of overall productivity has been gaining recognition and acceptance not only for its theoretical relevance but also for its practicality among policy makers and economic analysts.

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Some governments have begun to include the TFP growth rate as a target in national development plans. Our analysis will examine changes in agricultural productivity in MENA region (The countries considered in this study are Algeria, Egypt, Iran, Iraq, Israel, Jordan, Lebanon, Libya, Mauritania, Morocco, Saudi Arabia, Sudan, Syria, Tunisia, Turkey and Yemen. I drop the very small countries with negligible agriculture from the sample – Bahrain, Qatar, Kuwait, Oman and United Arab Emirates). Indeed almost all the countries of this region continue to be extremely vulnerable to weather and commodity price shocks due to their limited economic resource base. They are prone to high volatility in economic activety, and therefore it is crucial to identify their sources of growth.

The MENA region which is one of the largest producers and importers of food and feed grains in the world is a major global market for agricultural and food products. Indeed this region includes Egypt, the largest wheat importer in the world, and Turkey, one of the largest wheat producers. Agriculture importance in the economy is reflected by its significant contribution to the gross domestic product of the region. As illustrated by Table 1, the region's share of agriculture in GDP is decreasing in the majority of MENA countries as well as in the entire region with 12.61% in 1970 and 11.12% in 2000. Sudan had the

Table 1. Some indicators of Agriculture for all MENA countries

	Share of agriculture in GDP (%)	
Country	**1970**	**2000**
Algeria	9.21	8.77
Egypt	29.42	16.70
Iran	11.90[a]	15.11
Iraq	-	-
Israel	-	-
Jordan	11.64	2.26
Lebanon	9.01	11.92
Libya	2.39	5.04[b]
Mauritania	29.27	21.94
Morocco	19.93	13.83
Saudi Arabia	4.54	4.94
Sudan	43.61	41.15
Syria	20.16	22.65
Tunisia	17.03	12.35
Turkey	39.54	15.36
Yemen	-	14.07
Mean	12.61	11.12

[a]The value corresponds to the year 1974; - = not available; [b] The value corresponds to the year 1987. Source: WDI (2004) database.

highest shares in 1970 and in 2000, with 43.61% and 41.15%, respectively.

Agricultural productivity growth has been studied intensively during the last five decades. Development and agricultural economists have examined the sources of productivity growth over time and space (productivity differences between countries and regions). During the 1970s and 1980s a number of major analyses of cross-country differences in agricultural productivity used cross-sectional data. The majority of these studies focused generally on the estimation of the production elasticity and the investigation of the contribution of farm scale, education and research in explaining cross-country labor productivity differentials (Lau and Yotopoulos, 1989; Kawagoe et al., 1985; Kawagoe and Hayami, 1983, 1985; Hayami and Ruttan, 1970).

The recent increase in the number of papers investigating cross- country differences in agricultural productivity levels and growth rates is most likely driven by three factors. The first one is the availability of some new panel data sets, such as those produced by the FAO. The second factor is 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. The third factor is a desire to assess the degree to which the green revolution and other programs have improved agricultural productivity in developing countries. One of the recurring themes in the reported results in many of these studies is that less developed countries exhibit technological regression while the developed countries show technological progress (Fulginiti and Perrin, 1993, 1997, 1998, 1999; Arnade, 1998; Trueblood, 1996; Kawagoe et al., 1985; Kawagoe and Hayami, 1985; Lau and Yotopoulos, 1989).

Those studies show that growth of developing countries agriculture over the last half century is the outcome of resources increase instead of technical efficiency improvement of the resource use and new techniques adoption, or human capital development. This result is quite distressing, given the considerable advances that have been made in agriculture over the past fourteen years. For example, the “Green Revolution” of the late 1960s was characterized by spectacular improvements in the yields of many major food crops, and throughout the past four decades, huge advances have been made in irrigation systems, fertilizer use, and genetic engineering. Why, then, would agricultural produc-tivity in developing countries be declining?

The main proposed advantages of our study are the following (i) dispute the general idea of negative productivity growth in developing countries (ii) the importance of using regional technology frontier versus a global technology frontier (We measure here a relative productivity in Malmquist framework versus absolute productivity in other frameworks (e.g, Solow growth accounting) and (iii) providing up to date information on agricultural total factor productivity (TFP) growth over the past three decades (1970 - 2000) for MENA countries.

A focus on a more homogeneous geographical area such as MENA region will help us to identify the characteristics of this evolution in relation to geographical, social, or political circumstances of these countries. Our analysis will be based on the DEA technique to calculate Malmquist TFP index numbers. We use a regional technology frontier with similar agro- ecological and cultural features. The majority of MENA countries are characterized by water scarcity and limited arable land. Higher TFP would imply a shift in the production possibilities frontier of the agricultural sector away from the origin, leading to higher output from the application of technology and better use of resources.

The remainder of this paper is organized as follows. We provide in section 2 a more detailed review of the literature and present in section 3 the DEA and Malmquist TFP index methods. In section 4 we describe the data used and discuss our results. Finally we try to suggest appropriate policy implications and conclude in the last section.

Literature review

Agriculture productivity analyses performed to date show that most developing countries are experiencing relatively negative productivity growth with technical change being the main source of this regression. Kawagoe et al. (1985) showed agricultural productivity decrease in 22 LDCs, but an increase in the 21 developed countries included in the sample. Kawagoe and Hayami (1985) found similar results for the same data set using an indirect production function approach that is similar to the indexing approach except that input shares are estimated by using marginal productivities from an aggregate production function instead of prices. Lau and Yotopoulos (1989) found also in their analysis declining agricultural productivity for LDCs in the 1970s but an increase in the 1960s, although they used different functional forms (translog functional form and country effects).

Trueblood (1996) estimated a traditional Cobb-Douglas production function and also used the deterministic nonparametric methodology to estimate a Malmquist index. The models were estimated with quality- adjusted inputs using panel data covering 117 countries and 31 years. The study also found negative productivity growth in a significant number of developing countries. Fulginiti and Perrin (1997, 1998 and 1999) used an output-based Malmquist index to estimate agricultural productivity. They identified negative productivity growth in a set of 18 developing countries over the period 1961 - 1985. In their results, at least half of the 18 countries, including Argentina, Brazil, Korea and the Philippines exhibited negative productivity growth. “They also found for those countries that tax agriculture most heavily had the most negative rates of productivity change”. Their results lend a support to the results obtained earlier by Kawagoe et al. (1985), Kawagoe and Hayami (1985) and Lau and Yotopoulos (1989), using econometric approaches.

Trying to explain measured productivity decline in developing countries, Fulginiti and Perrin (1993, 1998) related poor productivity performance to economic policy. They found that those countries with heavy agriculture taxes had the most negative rates of productivity change. They suggested that price policies or other interferences with the agricultural sector might stifle potential productivity gains. Fulginiti and Perrin also suggested, as an alternative explanation, that the methods and data used in these studies may have inaccurately measured technical regression.

Arnade (1998) estimated agricultural efficiency change indices, technical change indices and productivity indices using nonparametric Malmquist indices for 70 developed and developing countries over the period 1961 - 1993. 36 of the 47 developing countries included in this sample showed negative rates of technical change, whereas most of the developed country indices rose or followed mixed paths. More recently, Suhuriyanto et al. (2001) found negative agricultural productivity growth rates in Asia during 1965 - 1980 and in Africa from 1971 to 1981. They also showed that the rates are improving during the subsequent years in both regions.

In contrast, recent studies of agricultural productivity growth in developing countries have showed positive and rapid growth. Coelli and Rao (2003) examined the growth in agricultural productivity in 93 countries over the period1980 to 2000. Their results showed an annual growth in total factor productivity growth of 2.1%, with efficiency change contributing by 0.9% per year and technical change providing the other 1.2%. There is little evidence of technological regression found in the earlier studies. Those results are explained as a consequence of the use of a different sample period and an expanded group of countries.

Pfeiffer (2003) analyzed agricultural productivity growth in a more homogeneous geographical area, the Andean community (Bolivia, Colombia, Ecuador, Peru and Venezuela) over the period 1972 - 2000. Production and input time-series data were used to estimate a parametric translog production function, a stochastic frontier production function and a nonparametric Malmquist productivity index to obtain the rate of total factor productivity growth. The results are consistent across methods and indicate that in contrast to previous studies, productivity growth in the Andean Community is positive and increasing over time. Furthermore, the TFP growth rates estimated are comparable to those of developed countries. Land quality, war, violence, and political freedom are important in understanding behavioral differences across countries.

In order to test the methodologies and the results of these studies, Pfeiffer (2003) suggested looking at more homogenous sets of developing countries sharing geographical, economic, and social characteristics.

Nin et al. (2003) re-examined the nonparametric procedure for estimating the Malmquist productivity index. They argued that the technical regression observed is principally the consequence of biased technical change together with the definition of technology used to estimate the Malmquist index. They eliminated this effect by applying a broader cumulative definition of technology than is normally used to estimate the Malmquist index. Their results using this new approach reversed the previous findings and showed that most countries in their sample of 20 developing countries experienced positive productivity growth with technical change being the main source of this growth.

Nin et al. (2009) estimated the Malmquist index for 59 countries for the period 1967 - 2003. The aim of their paper is to measure and compare agricultural TFP growth in China and India. They found that TFP growth was high in China, with an average annual growth of 2.11%. In India the TFP growth is slow and lower than in China but it was positive.

METHODOLOGY

One of the most popular approaches to measuring productivity changes is based on the calculation of Malmquist productivity index which was introduced by Caves et al. (1982) and based on distance functions. The innovation of Färe et al. (1994), showing that this index can be estimated using a nonparametric approach, has induced extensively its use for measuring and analyzing productivity. Productivity may grow because the production possibility set increases or because resources are better used Ten Raa (2008). This approach allows the decomposition of productivity growth into 2 mutually exclusive and exhaustive components:

i) The efficiency improvement of the techniques used to process the

inputs (catching up).
ii.) The innovation in technology (technical change).

TFP is measured in our study by the Malmquist index methods described in Färe et al. (1994) and Coelli et al. (1998. Ch. 10) (The Malmquist approach is less dependent on the parametric specification of the model). We use the Malmquist productivity index (MPI) as a measure of productivity change over time. The MPI is based on distance functions which allow describing a multi-input, multi-output production technology without the need to specify a behavioral objective. We consider here an output distance function. A production technology may be defined using the output set, P(x), which represents the set of output vector, y, which can be produced using the input vector, x.

That is, P(x) = {y: x can produce y} (1)

The output distance function is defined on the output set, P(x), as:

$$d(x, y) = \min \{\delta : (y/\delta) \in P(x)\} \quad (2)$$

The distance function, d(x, y), will take a value which is less than or equal to one if the output vector, y, is an element of the feasible production set, P(x). Furthermore, the distance function will take a value of unity if y is located on the outer boundary of the feasible production set and will take a value greater than one if y is located outside the feasible production set. The distance functions are measured by using DEA methods (DEA is a linear-programming methodology, which uses data on the input and output quantities of a group of countries to construct a piece-wise linear surface over the data points. This frontier surface is constructed by the solution of a sequence of linear programming problems-one for each country in the sample. The degree of technical inefficiency of each country (the distance between the observed data point and the frontier) is produced as a by-product of the frontier construction method) . As we consider the output distance function, the DEA method in this case seeks the maximum proportional increase in output production, with input levels held fixed.

The MPI needs are defined with respect to a reference period technology, therefore the MPI with respect to technology in any period *t* is:

$$M_t = \frac{d_t(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)} \quad (3)$$

An analogous output orientated MPI with period t+1 technology as the benchmark

$$M_{t+1} = \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_{t+1}(x_t, y_t)} \quad (4)$$

As it is difficult to choose between periods t and t+1 for the reference or benchmark period, we define an output orientated MPI as the geometric mean of (3) and (4), (Färe et al., 1994):

$$M_{t,t+1}(x_t, x_{t+1}, y_t, y_{t+1}) = \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)} \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_{t+1}(x_t, y_t)}\right]^{1/2} \quad (5)$$

This can be decomposed into technical efficiency change $(\Delta TE_{t,t+1})$ and technical change $(\Delta TC_{t,t+1})$ as follows

$$M_{t,t+1}(x_t, x_{t+1}, y_t, y_{t+1}) = \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)} \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_{t+1}(x_{t+1}, y_{t+1})} \frac{d_t(x_t, y_t)}{d_{t+1}(x_t, y_t)}\right]^{1/2} \quad (6)$$

This provides further insights into productivity changes since the first component,

$$\Delta TE_{t,t+1} = \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)}$$

, measures the change in technical efficiency over the two periods and the second component,

$$\Delta TC_{t,t+1} = \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_{t+1}(x_{t+1}, y_{t+1})} \frac{d_t(x_t, y_t)}{d_{t+1}(x_t, y_t)}\right]^{1/2}$$

, measures the change in technology over the 2 time periods. Greater than unity values for either of these components suggest improvement, while less than 1 values suggest the opposite. Efficiency change component here refers to the improved ability of a country to adopt the global technology available at different points of time whereas technical change measures the effect of shift in the production frontier resulting from technological advances on agricultural output.

Following Färe et al. (1994) and given that suitable panel data are available, we can calculate the required distance measures for the Malmquist TFP index using DEA-like linear programs. For each country, we must calculate 4 distance functions to measure the TFP change between two periods, t and t+1. This requires the solving of four linear programming (LP) problems assuming constant returns to scale (CRS) technology:

$$(d_t(y_t, x_t))^{-1} = \max_{\theta}$$

Subject to:

$$Y_t \lambda \geq \theta y_{it}$$
$$x_{it} \geq X_t \lambda \quad (7)$$
$$\lambda \geq 0 \, ;$$

$$(d_{t+1}(y_{t+1}, x_{t+1}))^{-1} = \max_{\theta}$$

Subject to:

$$Y_{t+1} \lambda \geq \theta y_{it+1}$$
$$x_{it+1} \geq X_{t+1} \lambda \quad (8)$$
$$\lambda \geq 0 \, ;$$

$$(d_t(y_{t+1}, x_{t+1}))^{-1} = \max_{\theta}$$

Subject to:

Table 2. Technical efficiency under constant returns-to-scale in selected years, by country.

Country	1970	1980	1990	2000
Algeria	1.000	1.000	1.000	1.000
Egypt	0.972	0.965	0.991	0.917
Iran	1.000	1.000	0.955	1.000
Iraq	0.915	1.000	1.000	0.507
Israel	0.874	0.974	0.996	0.944
Jordan	0.418	0.760	1.000	1.000
Lebanon	0.695	1.000	0.978	1.000
Libya	1.000	1.000	0.987	1.000
Mauritania	1.000	1.000	1.000	1.000
Morocco	0.736	0.734	0.963	0.910
Saudi Arabia	0.985	1.000	0.976	1.000
Sudan	1.000	1.000	0.998	1.000
Syria	1.000	1.000	1.000	1.000
Tunisia	0.956	1.000	1.000	1.000
Turkey	1.000	1.000	0.982	0.874
Yemen	1.000	0.929	0.940	1.000
Mean	0.909	0.960	0.985	0.947

$$Y_t \lambda \geq \theta y_{it+1}$$
$$x_{it+1} \geq X_t \lambda \qquad (9)$$
$$\lambda \geq 0 \text{ ;}$$

And

$$(d_{t+1}(y_t, x_t))^{-1} = \text{Max}$$
$$\theta$$

Subject to:

$$Y_{t+1} \lambda \geq \theta y_{it}$$
$$x_{it} \geq X_{t+1} \lambda \qquad (10)$$
$$\lambda \geq 0$$

Where;

y_{it} and y_{it+1} are M ×1 vectors of output quantities for the i-th country in period t and in period t+1, respectively;
x_{it} and x_{it+1} are K ×1 vectors of input quantities for the i-th country in period t and in period t+1, respectively;
Y_t and Y_{t+1} are N ×M matrixes of output quantities for all N countries in period t and in period t+1, respectively;
X_t and X_{t+1} are N ×K matrixes of input quantities for all N countries in period t and in period t+1, respectively;
λ is an N ×1 vector of weights; and θ is a scalar indicating the technical efficiency score.

Note that in LP's 9 and 10 where production points are compared to technologies from different time periods the θ parameter needs not be greater than or equal to one, as it must be when calculating standard output-orientated technical efficiencies. The data point could lie above the production frontier. This will most likely occur in LP 10 where a production point from period t+1 is compared to technology in an earlier period, t. If technical progress has occur-red, then a value of θ <1 is possible. Note that it could also possibly occur in LP 9 if technical regress has occurred, but this is less likely.

DATA AND RESULTS

The present study is based on data drawn from the AGROSTAT system of FAO statistics division (FAO, 2006) (The authors are grateful to the FAO for offering valuable data series on the internet and from the World Bank (WDI, 2004). They consist of two outputs (crops and livestock production) and six inputs (land, irrigated land, animal stock, labor, fertilizer consumption and agricultural machinery (number of tractors)). Output indices (1989 - 91 = 100) for crops and livestock obtained from the (WDI, 2004) are used for the outputs. Land is the total agricultural area. Irrigated land is the percentage of cropland. We adjust land quality with this variable. The number of cattle measured in livestock units is used as a proxy for animal stock. Total economically active population in agriculture is used as the labor variable. Land, animal stock and labor were obtained from the AGROSTAT system of FAO Statistics Division (FAO, 2006). Irrigated land, Fertilizers and agricultural machinery are obtained from the (WDI, 2004). Agricultural TFP indices are estimated for the 16 MENA countries over the period 1970-2000. The Malmquist indices are the product of efficiency change and technical change.

The results of our DEA and TFP calculations are summarized in this section. We provide information on the means of the measures of efficiency change, technical change and TFP change for each country (over the 31 year sample period) and the mean changes between each pair of adjacent years (over the 16 MENA countries).

Technical efficiency scores and their averages in 1970, 1980, 1990 and 2000 are reported in Table 2 for the full sample. Algeria, Mauritania and Syria are technically efficient in the 4 years. Egypt, Israel and Morocco aren't frontier countries in any of the 4 years. Note that the average technical efficiency score of 0.947 in 2000 implies that MENA countries are on average, producing 94.7% of the output that could be potentially produced using the observed input quantities. We notice that MENA region achieved the largest increases in mean technical efficiency over the period 1970 - 1980 and the largest decreases in mean technical efficiency over the period 1990 - 2000. The average technical efficiency was the highest during the year 1990.

This average technical efficiency change gives us information only on the "catch-up" part of the productivity story. In fact a country will have a positive efficiency change over time if it is catching up. The degree of catching up or the efficiency change can be related to institutional factors, as well as domestic and trade policies of specific countries. TFP change can also appear in the form of technical change (or frontier-shift). Tables 3 and 4 sum-

Table 3. Productivity index and components, 1970 - 2000

Country	Efficiency change	Technical change	TFP change
Algeria	1.000	1.009	1.009
Egypt	0.998	1.019	1.017
Iran	1.000	0.979	0.979
Iraq	0.980	0.999	0.979
Israel	1.003	1.013	1.016
Jordan	1.030	1.012	1.042
Lebanon	1.012	1.022	1.034
Libya	1.000	1.023	1.023
Mauritania	1.000	0.981	0.981
Morocco	1.007	1.011	1.018
Saudi Arabia	1.000	0.968	0.968
Sudan	1.000	0.995	0.995
Syria	1.000	1.002	1.002
Tunisia	1.002	1.024	1.025
Turkey	0.996	0.994	0.989
Yemen	1.000	0.982	0.982
Mean	1.002	1.002	1.004

marize the means of the measures of efficiency change, technical change and TFP change for each country over the 31-year sample period (1970 - 2000), and the sub periods (1970 - 1980, 1981 - 1990 and 1991-2000).

The mean efficiency change, technical change and TFP change for the 16 MENA countries over the period 1970 to 2000 are illustrated by Table 3. The average (across all countries) growth in TFP is 0.4 percent, which is due to 0.2 percent growth in efficiency change and 0.2% in technical change.

Table 4 compares the TFP index estimates for the period 1970 - 2000. We note that the estimates of the same index are made for three sub periods: 1970 - 1980, 1981 - 90 and 1991 - 2000. MENA countries are characterized on average by negative productivity rates until the 1990s and positive rates from 1991. Fortunately the positive increase offsets largely the earlier losses. The highest average growth in TFP, in the order of 2.7%, is recorded during the period 1991 - 2000.

In measuring TFP change for 115 developed and developing countries, Nin et al. (2003) found a 0.05% TFP growth for MENA region during the period 1965 - 1994. The estimates of TFP growth in Morocco, Libya, Algeria, Sudan, Tunisia, Iran, Turkey and Iraq are 1.05, 0.81, 0.57, 0.39, 0.07%, -0.38,-0.76 and -0.98%, respectively. Rao et al. (2004) found a 0.9% TFP growth for the MENA countries considered in the sample of 111 developed and developing countries using Malmquist indexes during the period 1970 - 2001. The estimates of TFP growth in Saudi Arabia, Morocco, Algeria, Egypt, Syria, Tunisia, Iran, Israel, Turkey and Iraq are 3.1, 1, 2.3, 0.9, 0.9, 1.5, 0.3, 0.8, 0.1 and -1.5%, respectively.

Nkamleu (2004) examined the growth in agricultural total factor productivity of 16 African countries using the data envelopment analysis over the period 1970 - 2001. It was found that, globally, during that period, total factor productivity has experienced a positive evolution in sampled countries. On average, total factor productivity has increased by 0.1% annually. This good performance of the agricultural sector was due to good progress in technical efficiency rather than technical progress. The region suffered from a productivity decreasing during the 1970s and made some progress during the 1980 and 1990s. The study also highlights the fact that technical change has been the main constraint of achievement of high le-vels of total factor productivity during the reference period in sub-Saharan Africa. Contrariwise, in North African countries, technological change has been the main dri-ving force of productivity growth. The estimates of TFP growth in Algeria, Egypt, Morocco and Tunisia are 3, -0.2, 0.6 and 1.4%, respectively.

Our results of TFP growth are not sensible to scale efficiency. When we consider the VRS assumption, the results of TFP growth do not change. Also Malmquist input-oriented methodology gives the same results as Malmquist output-oriented methodology. Nine countries in our sample are experiencing significant productivity growth and 7 exhibiting substantial productivity regress. Table 3 shows that among the 9 MENA economies, Algeria, Israel, Jordan, Lebanon, Libya, Morocco, Syria and Tunisia can be innovative and efficient at the same time. Jordan, Lebanon, Libya and Tunisia are the 4 countries with maximum TFP growth.

Jordan shows a 4.2% average growth in TFP, which is due to 3% growth in efficiency change and 1.2% growth in technical change. This result can be explained by the two food price riots and US-Jordan free trade effects.

Lebanon, Libya and Tunisia respectively exhibit TFP growth rates of 3.4, 2.3, and 2.5%. During the whole study, the contribution of Lebanese agriculture to GDP is between 9 and 12%. Lebanese agriculture could and should contribute more to the national economy. This could be realized through a more accommodating overall macroeconomic framework and through specific public policies that are more sensitive to the needs and requirements of a more productive and export oriented agricultural sector. It is inconceivable that the agricultural sector can flourish under an over-valued exchange rate and where scarce resources such as water are not valued at their replacement cost. Lebanese farmers have shown a great proclivity to use the correct factor proportions and to respond correctly and speedily to changed economic circumstances. The growth of technical change is 2.2% during the whole period 1970 - 200. What are missing perhaps are the institutional framework and the correct signals that will allow farmers to adjust appropriately and correctly to economic signals and opportunities. Lebanon is relatively well endowed with water but this water needs to be conserved and its quality preserved. Water needs to be priced at its shadow price. There is no room for waste and efficiency calls for limiting waste and for an appropriate price regime (Jaber, 1997).

Table 4. Productivity index for 1970 - 2000 and sub-periods.

Country	1970 - 2000	1970 - 1980	1981 - 1990	1991 - 2000
Algeria	1.009	0.986	1.010	1.018
Egypt	1.017	1.008	1.011	1.038
Iran	0.979	0.934	0.976	1.022
Iraq	0.979	0.978	1.015	0.952
Israel	1.016	1.020	1.003	1.017
Jordan	1.042	1.038	1.033	1.038
Lebanon	1.034	1.067	0.984	1.054
Libya	1.023	1.006	0.983	1.080
Mauritania	0.981	0.959	0.942	1.011
Morocco	1.018	0.986	1.032	1.032
Saudi Arabia	0.968	0.885	0.997	1.046
Sudan	0.995	0.973	0.971	1.030
Syria	1.002	1.009	0.970	1.026
Tunisia	1.025	1.023	1.025	1.026
Turkey	0.989	0.948	1.005	1.008
Yemen	0.982	0.927	0.987	1.035
Mean	1.004	0.983	0.996	1.027

Our estimate of TFP growth in Libya is 2.3% which is due only to technical change growth. Libya's agriculture is the second-largest sector in the economy, Libya depends on imports in most foods. Climatic conditions and poor soils severely limit farm output and domestic food production meets only about 25% of demand. Domestic conditions limit output, while higher incomes and a growing population have induced d food consumption rising. The surface water scarcity in Libya, has conducted agricultural projects such as the Al Khufrah Oasis to rely on groundwater pumping. Libya's primary agricultural water resources remain the Great Manmade River, in spite of significant investments in desalinization to meet growing demand (World Bank, 2006).

Tunisia's estimate of TFP growth is 2.5% which is due to 0.2% growth in efficiency change and 2.4% in technical change. This result implies an improvement in productivity through either technical change or efficiency gains. A major challenge facing the agricultural sector in Tunisia is how to increase farm production to meet the changing food needs without degrading the natural resource base. We want to mention that Tunisian decision makers have designed their strategies to increase agriculture productivities within those environmental constraints. Over the last 2 decades of the 80's and 90's, the agricultural sector in Tunisia has undergone substantial structural changes with a profound movement of liberalization and privatization. Input subsidization schemes that provide little incentives for resource conservation, price support programs that distort market allocation of resources and heavy border protection making food more expensive for consumers have been increasingly recognized as inefficient ways to achieve higher levels of productivity and consequently food security.

An important milestone within this time period is the agricultural sector adjustment program initiated by the government in 1986 to (i) remove the major sources of price distortions that adversely affect efficiency and productivity (ii) transfer marketing functions that are under state control to the private sector and (iii) improve the public sector management, which entails increasing privatization (Dhehibi and Lachaal, 2006).

Dhehibi and Lachaal (2006) investigated the patterns of productivity growth in Tunisian agriculture during the period 1961 - 2000. Results indicate that on average, productivity growth increased at an annual rate of 3.6% over the whole period of investigation. Total factor productivity contribution to output growth decreased from over 4% in both the 1961 - 70 and 1981- 90 periods to less than 3% in both the 1971 - 80 and 1991- 2000 periods.

Morocco exhibits TFP growth rate of 1.8% during the whole period 1970 - 2000. We note that the estimates of the same index are respectively -1.4, 3.2 and 3.2% for 3 sub periods: 1970 - 1980, 1981 - 90 and 1991 - 2000. Morocco is characterized on average by negative productivity rates until the 1980s and positive rates from 1981. Fortunately the positive increase offsets largely the earlier losses.

Agriculture TFP growth in Morocco needs to be higher because even agriculture accounts for less than 20% of the country's total GDP, it employs nearly 40% of the local labor force and drives the country's economic growth. Morocco is probably the most volatile grain production country in the world. Given that both agricultural policy and the climate affect agricultural growth in Morocco, there is a belief that the current agricultural policy is misaligned with the new climatic reality in the country. The incentive structure of the past, when rainfall was adequate, has become counterproductive since droughts are more frequent now. How to align the 2 are still at the discussion stage and different research needs to assess alternative policy options for the future has been identified (Tyner, 2001).

Israel shows a 1.6% average growth in TFP, which is due to 0.3% growth in efficiency change, and 1.3% growth in technical change. The structure of Israel's economy has changed unrecognizably since the establishment of the state. In 1953 agriculture accounted for 12% of GDP, manufacturing for 21% and services for 25%. By the beginning of the 1990s, however, agriculture had dropped to 4.5%, manufacturing had risen to 30% and services had risen to approximately 40%. Nevertheless, these changes however significant do not accurately represent what happened. In manufacturing, for example, the share of the traditional labor-intensive industries such as textiles-plummeted, while that of human-capital-intensive industries such as electronics, optics, and scientific instruments rose. The internal changes within manufacturing and the service sector were no less important than the increase in their share of GDP and the decline in that of agriculture (Helpman, 2003).

Egypt is innovative but not efficient. It shows a 1.7% average growth in TFP, which is due to 1.9% growth in technical change, and 0.2% regression in efficiency change. TFP growth in Egypt is higher in the 1990s than in the 1970s and 1980s (respectively, 3.8, 0.8 and 1.1%). Government investment in agriculture and irrigation has been very modest during the 1970s and 1980s. The share of agriculture and irrigation in total public investment fell from about 23% in the mid-1960s to about 8% in the mid-1970s. Therefore, compared to other sectors, agriculture has shown the slowest growth with an average increase of about 2.7% per year and 2.5% per year, between 1965 and 1980, and 1980 and 1990, respect-tively.

In the early 1970s agriculture contributed about 28% to GDP but employed about 53% of the work force. By the end of the 1980s, agriculture's contribution to GDP declined to 17% and its share of total employment dropped by nearly one third. Agricultural growth was low (only 2.7% from 1965 to 1980) and declined to 2.5% during 1980 - 1990. Agriculture's share of all goods exported declined from 75% in 1970 to 15% in 1989. Self-sufficiency ratios for most food commodities declined during the 1970s and 1980s. Major shifts took place in the cropping pattern from 1970 to 1990 (Goueli and El Miniawy, 1993).

Wheat and flour subsidies were the most important among food subsidies during the 1960s and most of the 1980s. In mid-1991, the government adopted a wide-range program of economic reform which resulted in some positive effects on foreign exchange and budget deficit. Substantial progress had been made following the reform of agricultural policies. All input subsidies had been eliminated by 1993. Public ownership of newly reclaimed land was prohibited with all such land allotted to private individuals and companies. Control of private sector of farm product processing and marketing firms had been removed (Goueli and El Miniawy, 1993).

Syria has low rate of agriculture productivity during the whole period 1970-2000. Our estimate of TFP growth in Syria is 0.2% which is due to only technical change growth. TFP growth in Syria is higher in the 1990s than in the 1970s and 1980s (respectively, 2.6, 0.9, and 3.0%). During the eighties, Syria's agriculture TFP growth is negative. Hence in 1987 the Syrian Government star-ted to gradually reform the country's agricultural policy. The objective was to phase out centrally planned features and to gradually switch to indicative planning procedures which are associated with more liberal agricultural sector policies. This approach has shown positive results in terms of output development and agriculture TFP growth in the 1990s. At the end of the 1990s, Syria became a net exporter for many agricultural products (cotton, wheat, barley, sugar beets, fruits and vegetables). Furthermore, it is worth pointing out that this gradual approach to reforms has prevented a sharp decline of agricultural output in Syria. In contrast, the countries of central and Eastern Europe and the former Soviet Union generally have chosen a rather sudden abolition of the central plan and have experienced significant agricultural output decline in the first years after liberalization. Many of these countries have not yet recovered from this. It is also worth mentioning that the liberalization level of agricultural policies is very high on the international policy agenda.

The countries, which exhibit TFP regression, are Iran, Iraq, Mauritania, Saudi Arabia, Sudan, Turkey and Yemen (Iran and Iraq experienced wars during the period studied. The results for Iran, Iraq, Mauritania, Yemen, Turkey and Sudan are less dramatic with only a -2.1, -2.1, -1.9, -1.8, -1.1 and -0.5% annual average productivity decrease rates, respectively. In the case of Iran, Mauritania, Saudi Arabia, Sudan and Yemen, negative productivity values are explained only by technical regression (a negative rate of technical change). Agriculture productivity in Iraq and Turkey is declining due to regression in technology and technical efficiency together.

In the case of Saudi Arabia, the annual average productivity growth rate is -3.2% during the whole period 1970-2000. It is -11.5, -0.3, and 4.6, during the periods 1970 - 1980, 1981 - 1990 and 1991 - 2000, respectively. The results of 1970s and 1980s are explained by the reaction to the western debate about "food power" retaliation against OPEC at that time, which led the Saudis to subsidize wheat producer prices at seven times the world price and used very expensive desalinated water, all in an effort to provide some food security that was less vulnerable to trade embargo. Also, there is a significant body of literature which addresses the means by which natural resource abundance may hinder overall develop-ment. In this case we assume that both government and private resources are simply diverted towards oil produc-tion. Furthermore, oil revenues provide a means of finan-cing food imports rather than relying on domestic produc-tion, perhaps relieving the need to use agricultural inputs more efficiently (see Sachs and Warner 1995, for example). Since the nineties Saudi Arabia has developed a very modern livestock and dairy sector.

The declining agriculture productivity in Iran is strongly related to regime and policy changes. We observe TFP regression mainly during the sub periods 1970-1980 and 1981-1990. The last one is the period of the war against Iraq. The post war period is characterized by a TFP growth of 2.2%.

The declining agriculture productivity in Iraq is the result of wars and the increasing neglect from govern-ment over the years. The average growth in TFP is -4.8 % during the period 1991-2000. The post-Gulf War 1991 experience was interesting with embargo, oil-for-food, and increasingly desperate and inappropriate agricultural production measures taken (major wheat fungus problems developed). Agriculture is Iraq's largest employer, the second largest value sector, and an effective engine for promoting stability through private sector development, poverty reduction, and food security. The revival of a dynamic, market-driven agricultural sector will strengthen private business, increase income and employment opportunities, and meet the food requirements of the Iraqi people.

The results for Turkey are surprising. Turkey is a large country with a large agricultural sector. In the year 2000, 35% of its labor force continued to be employed in agriculture and 13 % of its GDP was generated in the agricultural sector. Turkey is an important regional wheat and tobacco exporter. It has undergone some policy changes over the years regarding support price levels, etc. The growth experience of Turkey encompasses a wide-ranging set of historical, political and economic events. Turkey today is typically cited among the largest emerging market economies that are rapidly becoming a major force in the world economy (Ismihan and Metin-Ozcan, 2006).

TFP regression in Yemen and Mauritania is mainly explained by the ongoing stagnation and poverty. Although Sudan is a predominately agricultural economy, agricultural TFP growth is -0.5% during the overall period of study, 1970 - 2000. Agricultural TFP growth is -2.7, -2.9 and 3.0% during the sub periods 1970 - 1980, 1981 - 1990 and 1991 - 2000, respectively. The change in the TFP agriculture growth of Sudan since the 1990s could be attributed to a number of factors which include economic reforms; favorable weather conditions affecting agriculture, high investment in oil sectors and related services, and the increase of oil exports. Sudan is considered the largest country in Africa and ninth in the world with a varied ecological zones and diverse agricultural base accounting for 40% of GDP. Growth rates showed fluctuating trends and oil has emerged as a major source for economic growth and revenue for the government. The growth rate of agriculture GDP was -1.2% during the period 1986 - 1990, 0.7% during the period 1991 - 1995, and 10.9% during the period 1996-2000. The constraints which are besetting the performance of the agricultural sector in Sudan are multiple: lack of strategic planning planning for different agriculture sub-sectors, low priority accorded to the sector, inadequate complementarities and coordination of macroeconomic and sectors po-licies, instability of production and low productivity, under utilized efficiency of human resources, meager budget allocated for agricultural research, inadequate social and physical infrastructure, and weakness of laws governing lease and use of land (Allam, 2004).

Table 5 shows the annual averages (averaged over the 16 countries) of efficiency change, technical change and TFP change. We can see that over the whole period there has been no efficiency regression and no technological regression, though for some individual years, there has been some evidence of technological regression and efficiency regression. It is possible that the agricultural productivity decline in some of those years could be due to unfavorable weather conditions. There are also several years where technological regress has been observed. This is possible in data envelopment analysis if countries defining the frontier move inwards (due to adverse weather conditions, etc.). In this case the estimated production frontier may also move inwards, leading to a negative technical change or technological regression. The highest TFP growth of 7.6% is between 1995 and 1996.

Conclusion and policy recommendations

This paper analyses agricultural productivity growth in MENA countries over the period 1970 - 2000 using a nonparametric Malmquist index. Our results weaken the previous findings indicating the decline of agricultural productivity in developing countries. Our estimations show that measured agricultural productivity in MENA countries is generally increasing, especially during 1991 - 2000, with technical change being the main source for this growth. However this result is not uniform across the entire MENA region. Indeed 9 countries are characterized by productivity gains while the seven others exhibit productivity losses. Declining productivity seems to affect countries suffering from wars such as Iran and Iraq. The performance of the global region is better during the 1990s than in the previous 2 decades.

This result may also mean that any stagnation in innovations or technical progress, perhaps due to political, economic or social conditions, would induce a decline in agriculture total factor productivity growth in the region. Sustained growth in agricultural productivity will generate several positive feedbacks. First, the release of valuable resources for other sectors thereby inducing further economic growth.

Second, higher levels of agricul-tural productivity would reduce food prices and therefore increase consumers' welfare. And finally, in the context of an open economy, productivity growth would improve the competitive position of a country's agricultural sector. TFP growth in MENA region during the period 1970-2000 is mainly attributed to changes in the technical component. But ag-

Table 5. Annual mean efficiency change, technical change and TFP change, 1970 – 2000.

Year	Efficiency change	Technical change	TFP change
1971*	1.064	0.974	1.036
1972	1.018	0.963	0.980
1973	0.987	0.890	0.878
1974	1.016	1.026	1.042
1975	0.985	0.940	0.926
1976	0.960	1.041	0.999
1977	1.048	0.984	1.031
1978	0.959	1.001	0.959
1979	1.011	0.959	0.970
1980	1.030	0.993	1.023
1981	0.992	1.041	1.033
1982	1.014	1.058	1.074
1983	1.002	0.946	0.948
1984	1.024	0.947	0.969
1985	0.992	1.004	0.996
1986	0.989	1.055	1.044
1987	1.017	0.959	0.974
1988	0.990	0.978	0.968
1989	0.989	1.017	1.007
1990	1.022	0.970	0.991
1991	1.005	1.039	1.044
1992	0.983	1.062	1.044
1993	1.018	1.007	1.025
1994	0.979	1.072	1.050
1995	0.976	1.083	1.057
1996	1.007	1.068	1.076
1997	0.993	0.968	0.961
1998	1.000	1.068	1.067
1999	0.994	0.943	0.937
2000	0.996	1.035	1.031
Mean	1.002	1.002	1.004

* Note that 1971 refers to the change between 1970 and 1971.

ricultural productivity also depends critically on on the efficiency of farmers.

One of the main objectives of this study is to help policy-makers to design optimal policies enhancing agricultural productivity growth in MENA countries. Such policies will be based on the improvement of the infrastructure (such as irrigation, roads and electricity) and training to achieve farmer's technical efficiency, as well as the improvement of technology in the form of research and development. Higher TFP would imply a shift in the production possibilities frontier of the agricultural sector away from the origin, leading to a higher output by the application of technology and better utilization of resources.

Thus on the basis of our findings, we suggest that policy makers complement the technical changes which actually explain the productivities growth in the MENA region, with measures improving the efficiency use of the different inputs and mainly the labor per unit areas.

We would like to point out that the negative productivity trends indicated by the previous studies are not the product of the used methods but the result of the inappropriate sample of the countries included in their empirical investigations. Indeed our findings are mainly the result of our choice of a homogeneous region composed of countries with similar agro-ecological and cultural features and sharing the same geographical, economic, and social characteristics.

This study constitutes the first attempt towards agricultural TFP analysis in MENA. We would mention that this analysis was focused entirely on nonparametric productivity measurement. Though the results are quite plausible and meaningful, we are aware of the data limitations and the need for further researches in this area. Future work should use parametric or semi parametric distance functions to study the robustness of the findings to the choice of methodology.

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