Measurement of Total Factor Productivity in Agriculture: Study on a Panel of Mediterranean Countries (1980-2012)

DOUMI Ali*

Mohammed V Rabat University–Morocco

Abstract In this article we explore the evolution of production Total Factor Productivity (TFP) in the agricultural sector of ten Mediterranean countries. Our sample is composed of ten Mediterranean countries, including five countries of the south and eastern Mediterranean (Morocco, Algeria, Tunisia, Egypt and Turkey) and five countries of northern Mediterranean (Portugal, Spain, France, Italy and Greece). For this, our comparative analysis of the evolution of production factors' total productivity and its two components in terms of technical efficiency and technological progress was achieved using two different methods over the period 1980-2012. This is the parametric generalized method of moments in system (GMM-system) of Arellano-Bover (1995), and the non-parametric method by envelopment analysis approach data (DEA), with respect to the DEA-Malmquist model. The results obtained by the two methods converge, placing Morocco in penultimate position, ahead of Portugal and behind the rest countries of the sample. Indeed, Morocco has relatively experienced positive development of TFP during the last two decades, except for the years 1995 and 2007 when Morocco has experienced a severe drought.

Keywords: total factor productivity - generalized method of moments in system (GMM-system) - dynamic panel - data envelopment analysis (DEA) - Malmquist index.

JEL Classification: C14, C23, E23

1. Introduction

We consider, in most cases, that an increase in productivity reduces the production cost of all goods, to raise the living standards of citizens, increase business profitability and improve competitiveness of the national economy. This is why productivity is a widely considered phenomenon in the development of economic policies.

Thus, productivity growth is the foundation for improving the real incomes and welfare. Slow productivity growth limits the growth of real income and increases the risk of conflicts over income redistribution (Englander and Gurney, 1994). Consequently, the level measurements and the productivity growth are particularly important economic indicators.

In principle, productivity is a rather simple indicator. It describes the relationship between production and the factors necessary to get it. Despite the apparent simplicity of this concept, the calculation of productivity give rise to a number of problems, which become crucial when looking for a comparison between one country and another in terms of growth and the level of productivity either at the economy level or at the different sectors one.

Basically, measures of productivity[1] can be classified into two categories: (i) monofactorial productivity measures (they relate a measure of output to a measure of a single production factor) and (ii) multifactor productivity measures (relating a measuring the output to a set of inputs). We also distinguish what is particularly interesting at the sector level or the company: Firstly, measures relating gross output to one or many factors of production and, secondly, those using a concept based on the added value to capture changes in production.

Thereby inasmuch as the evolution of concerns about food security and natural resources, and the gradual opening of agricultural markets during the recent wave of globalization, and for which Morocco is an agricultural country, study and analysis of total factor productivity in the agricultural sector in Morocco, and the comparison of this TFP with the evolution in the main competitor countries are required.

The main objective of this article is to explore the evolution of the overall productivity among the production factors in the agricultural sector of ten Mediterranean countries using two different methods. This is the parametric generalized method of moments in system (GMM-system) Arellano-Bover (1995), and the non-parametric method by data envelopment analysis approach (DEA) with respect to the DEA-Malmquist model.

The study is conducted using a panel data, and it has two specific objectives:
• Determine changes in total factor productivity in the agricultural sector of the considered countries in the sample.
• Compare the evolution of the Moroccan agriculture performance, with the main competitor counties.

The paper is structured as follows. Section 2 outlines the theoretical foundations. Section 3 presents the empirical framework of both estimation methods, the data used and the estimation results. Finally, Section 4 draws the conclusions of the present study.

2. Literature Survey

2-1 Contents of economic thought

The notion of productivity has always been devoted a particular attention in the economic mechanisms, from the physiocrat theory to the neoclassical theory of distribution, with divergent interpretations between the different researchers. This interest has been the source of a remarkable evolution of the economic and microeconomic theory of production. Indeed, the productivity theory is from an ancient origin, many authors have focused on the notion of productivity namely: JB- Say, Marx, Eugen von Böhm-Bawerk, Pareto and others, and each author explain the theory productivity differently. Note that the word itself is attributed to François Quesnay.

The concept of productivity became more precise with physiocrats's work such as Quesnay (1767), which considers that the concept of productivity is important in all this it is a way to measure agricultural performance. He deduces, what will be described later of a surplus agricultural theory in 1759. Turgot establishes on the contrary, that the earth provides

[1]Voir le manuel de l'OCDE, sur la mesure de la productivité.

diminishing returns as the cultivation measuring of less fertile land. In 1798, Malthus retake up this argument talking about the "limited output power of the earth" in his book "An Essay on the Principle of Population."

Classical authors admitted the theory of capital accumulation as a fundamental source of economic growth. They agree on the fact that the opportunities for growth that the division of labor and inventions offered the agricultural productivity differs radically from those offered to the industry. In industry the progress of inventions cancel any tendency to diminishing returns, unlike what happens in agriculture, based on natural resources. The progress of inventions would be unable to offset the effects of diminishing returns, insofar as capital returns and labor in the presence of a rigid land supply are a fundamental constraint to economic growth.

Contrary to the predictions of the classical model on the rigid earth offers. Schulz (1964), demonstrated that the share of land in national income declined during the economic development process and that technical progress allowed the agriculture to emerge of constraints that an resource offers a significant weight on growth.

In this context of agricultural development, Yujiro Hayami and Vernon Ruttan (1971-1985), are projecting their thoughts, endogenous growth in a long-term dynamic perspective called "induced innovation". The authors propose to develop an integrated theory of development compared to existing theories of agricultural development. Their ideas consist on considering the technical and institutional progresses are only depending on the factors offer and products demand. This is a neoclassical approach presented as an extension and combination of Schutz (1964) and Kuznetz’s works (1966). Indeed, Theodore W. Schultz’s book (1964), "the transformation of traditional agriculture" suggests that the simple reallocation of resources in traditional farming systems can not bring any significant productivity growth. There is only the possibility of strong growth, in technical progress: new breeding techniques, variety of improved seeds source of energy more efficient and cheaper fertilizer. The investment in activities, such as agricultural research and farms formation, leads to the provision of new production factors known to promote the growth of agricultural production. The Agricultural Development in Schultz’s theory concords with a more general point of view with that of Simon Kuznetz (1966). In his book "modern economic growth", the author suggests that the creation of economic and social institution for the systematic application of scientific knowledge to the economic activity constitutes the primary source of sustainable growth in productivity and per capita income.

For this, Yujiro Hayami and Vernon Ruttan (1971), exhibited, as a basic assumption for a rapid growth success in agricultural productivity, that each country must be able to produce an agricultural technology that is first suited to its environment and that is as economically viable. This hypothesis was presented in a more formally way in a "induced innovation" model. This model explains the process by wherein the induced technical progress, incorporated in new productive inputs are made. Indeed, according to those authors, the induced technical and institutional innovation depends on how farmers, agribusiness entrepreneurs, researchers and government officials react to resource endowments and supply and demand changes. The authors' analysis that concerns the specific development process of the agricultural sector was based on international comparisons of chronological series and of cuts on production levels, productivity and factors production in the agriculture. This comparison will allow, therefore, the generalization of the technological progress and agricultural growth models that were highlighted by experiences in different countries. It will allow to test the mutual interactions between the endowments of resources, the technical progress and the institutional innovation. For this, the authors have studied the example of the United States and Japan that have managed their growth of production and agricultural productivity while having different resource endowments. Their successes were attributed to their specific institutions that have allowed the appropriate technology diffusion to the environment of each country and economically viable.

2-2 Different approaches of productive efficiency measure

The economic theory of productivity measurement goes back to the works conducted by Jan Tinbergen (1942) and Robert Solow's work (1957). These authors formulated productivity measures in a production function context, and are related to the analysis of economic growth. Since then, this discipline has considerably grown, especially after the major contributions made by Jorgenson Dale, Griliches Zvi (1967) and Diewert Erwin (1976). Nowadays, the approach to the measurement of productivity by the production theory is consistent and well-established. It also relies on business theories and indices, as well as national accounts.

In the literature, many methods of measurement of the TFP were developed over the past decades. These various measurement methods can be classified under two groups, depending on whether we use them in a parametrically way or not. For non-parametric methods we distinguish, the indices method and the one of the data envelopment analysis (Data Envelopment Analysis, DEA). Parametric methods are grouped into three categories: (i) the so-called analysis of the stochastic frontier, (ii) the semi-parametric method and (iii) the generalized method of moments. The diversity of these methods, both in their method of calculation and their assumptions, suggests that each is more or less appropriate depending on the planned study cases.

Each of these TFP measurement approaches has its advantages and disadvantages. The choice to make depends on the purpose that we set to ourselves by measuring productivity and, in many cases, the availability of data. In our study of total factor productivity in agriculture, we chose two estimation approaches. The first parametric approach called generalized method of moments in system (GMM-system) developed by Arellano-Bover (1995). The second approach is nonparametric by the envelopment analysis approach data (DEA), by referring to the DEA-Malmquist model.

3. Theoretical Model

3-1 Parametric approach by the stochastic frontier method

Our approach to measure the total factor productivity is based on the work of Marion Dovis's work (2009)[2], which is estimated by various methods, TFP from a panel of Turkish companies on a period of 1983 to 1991. For our approach estimation of the total factor productivity in agriculture, we use a panel of ten Mediterranean countries, over 1980-2012, taking back the model used by Marion to apply Dovis in this study.

3-1-1 Econometric Framework

[2]View marion Dovis (2009) to estimate TFP measurement by different methods

Assuming that the production function specific to each country can be represented by a Cobb-Douglas's function (CD), we measure the TFP as the difference between gross amount of production and those of factors production.

Our basic function production can be written in a log-linear form, using a set of input:

$$Y_{it} = \alpha_t + \sum_j \beta_j X_{ijt} + (w_i + w_{it} + \varepsilon_{it})$$

$$w_{it} = \lambda w_{it-1} + \tau_{it}$$
$$\tau_{it}, \varepsilon_{it} \rightarrow MA(0)$$

With Yit the logarithm of the output represented by the agricultural production of the country i during the year t, Xijt the logarithm of the explanatory variables are: Capital stock, Labor, and the national rainfall index, αt a specific temporal effect. The productivity term is modeled with wi an individual specific fixed effects and wit an autoregressive shock of order one (IλI<1), (λis an autoregression parameter model) εit is the error term of measurement. The introduction of an autoregressive term error in the global error term allows to get a dynamic relationship. The aim is to estimate the parameters βj, and λ. The dynamic representation of the model is:

$$Y_{it} = \lambda Y_{it-1} + \sum_j \beta_j X_{ijt} + \overset{*}{\alpha} + \overset{*}{w_i} + v_{it}$$
$$\overset{*}{\alpha} = \alpha_t - \lambda\alpha_{t-1}$$
$$\overset{*}{wi} = w_i(1-\lambda)$$
$$v_{it} = \tau_{it} + \varepsilon_{it} - \lambda\varepsilon_{it-1}$$

$\overset{*}{w_i} + \overset{*}{v_{it}}$ Are uncorrelated random disturbances

Y_{it-1} Represents the lagged dependent variables.

We start by estimating the dynamic production function, for this, it is necessary to compensate for the biased endogenous because the model contains a lagged variable dependent and therefore the estimation parameter poses several challenges, including the possible correlation of the variable dependent delayed with the disturbance term.

We use the GMM approach system, this approach is to estimate a two-equation system, comprising the differentiated equation and the initial equation.

The conditional moments are necessary to provide the tools, because the delayed outputs are gonna be correlated with the composite error νit through εit. Thus, the production function first difference and the level production function are estimated jointly as a system with appropriate set instruments for each equation.

Productivity will be calculated by the following term and without excluding the random error term:

$$LnPTF_{it} = \hat{w}_i + \hat{w}_{it} + \hat{\varepsilon}_{it}$$

The calculated productivity is the difference between the observed and the predicted output by an estimated production function. This represents the technical efficiency of the agricultural sector (more the result is higher and more efficient the agriculture will be) but does not exclude the measuring error. Technical progress is then in the αt term.
This approach's advantages are based on the elimination of the through endogenous considering the measurement error. It also allows testing the validity of the used instruments. However, the main weakness of this measure is that it does not dissociate the technical efficiency of the statistical noise. In other words, when we are estimating TFP by the GMM method, the measurement obtained includes both factors under and out control of the firm.

3-1-2 Data

The empirical application of this study is based on panel data at the national level for some southern Mediterranean countries, namely Algeria, Morocco, Tunisia, Egypt and Turkey, involved in the partnership agreements with the EU and some EU countries presenting high potential in agriculture such as France, Greece, Italy, Portugal and Spain for the period 1980-2012.

These data come from the FAO's data basis, the data used identify the information about the production and the means of agricultural production in the considered countries. The variables used in the analysis are defined as follows:

- The production, represents the market value of food and agricultural products at the time of their production, expressed in constant terms, the value of aggregate production refers to the net production notion.
- Capital stock, estimated by fixed assets which include assets used in the production process, namely the developed land, livestock, structures used for the animal production and machinery and tools.
- Labor or variable work is captured by total employment in thousands in the agricultural sector, the variable is expressed in number of employees in the agricultural sector.
- The national rainfall index (NRI) calculated taking into account the different climates that exist in each country over a period of one year, this index is weighted by rainfed agricultural area to express the rainfall index by a unit of land cultivate rainfed 1000ha.

Data are extracted from the databases FAOSTAT, ILO, CIHEAM and the WB. All data were converted to logarithms.

3-1-3 Results of the estimation of the production function by the system GMM method

Table 1 reports the estimated coefficients of the system GMM method. The result is estimated by including temporal effects, individual and sectoral. The test Hansen and autocorrelation at the order 2 permit to confirm the statistical validity model. Thus, for Hansen's test, for level instruments and in first difference, the null hypothesis that the instruments used in the estimation are not correlated to the error term and accepted. Also the null hypotheses of an autocorrelation absence in residuals of order 2 are accepted. The measurement of total factors productivity, in of technical efficiency terms and thus presented in Appendix A.

3-2 nonparametric approach by the method DEA- Malmquist

In this approach, we decompose the productivity term in technical efficiency terms and in terms of efficiency related to technical progress through the Malmquist productivity index. Our sample for this approach application is the same as the one already used in the parametric approach cited in the previous section with the same database and the same period (1980 to 2012). Our empirical study is based on the data envelopment analysis (DEA) method founded on linear programming, which adapts perfectly to a production multi-outputs / multi-inputs or mono-output / multi-inputs study as in our case. This method determines the efficiency frontier in terms of the best practice. Each unit is considered a decision-making unit (DMU) in our study corresponds to one of our sample countries.
Given two sets of production:

$$S^t = \left\{ \left(X^t, Y^t \right); X^t can\ produce Y^t \right\}$$
$$S^{t+1} = \left\{ \left(X^{t+1}, Y^{t+1} \right); X^{t+1} can\ produce Y^{t+1} \right\}$$

Where (X^t, Y^t) and (X^{t+1}, Y^{t+1}) are respectively the amounts of inputs and outputs in both periods t and t + 1. These quantities are defined and t = 1 ......T.

From these two sets production and using DEA's method, one can construct a non-parametric frontier of production, which will thereafter permit to carry out efficiency measures for each DMU. For that DEA consists of solving for each DMU and with T periods (3T-2) linear program under constant returns to scale assumption (CRS), the assumption of variable returns to scale (VRS) , will lead to the calculation of additional programs with an extra constraint λ_i (convexity constraint) with. $\sum_{i=1}^{n} \lambda_i = 1$. In this case the number of program to calculate for each DMU Passes of (3T-2) to (4T-2). N for decision-making unit, the linear program number will be: N * (4T-2). In our study, the number of DMU corresponds to 10 countries over 32 years, so the total number of linear program to solve is: N * (3T-2) in the case of CRS where N * (4T-2) in the case of VRS.

According to the constructed distance function by the DEA method, we can establish four distance functions oriented output or input which may be determined by combining the borders t and t + 1of one part, and on the other hand the inputs quantities efficiency and outputs in t and t + 1, each measuring a specific relative efficiency.

The four components of the distance function are calculated as follows:

1. $D_o^t\left(y^t, x^t\right)$ Function Remote period t with the inputs and outputs of the period t;
2. $D_o^{t+1}\left(y^{t+1}, x^{t+1}\right)$ Function distance at time t + 1 with the inputs and outputs of period t + 1;
3. $D_o^t\left(y^{t+1}, x^{t+1}\right)$ Function Remote period t with the inputs and outputs of period t + 1;
4. $D_o^{t+1}\left(y^t, x^t\right)$ Function distance at time t + 1 with the inputs and outputs of period t.

For the four function components mentioned above, corresponds to four linear programs that we will have to solve in order to calculate the productivity index Malmquist. We present on the basis of variable returns to scale (VRS), the four linear programs to output orientation of each component of the distance function:

$$\left[D_o^t\left(y^t, x^t\right)\right]^{-1} = Max\theta, \lambda\theta,$$
$$S / C$$
$$Y^t\lambda \geq \theta y_i^t$$
$$X^t\lambda \leq x_i^t$$
$$\lambda \geq 0 \qquad \text{(PL1)}$$

$$\left[D_o^{t+1}\left(y^{t+1}, x^{t+1}\right)\right]^{-1} = Max\theta, \lambda\theta,$$
$$S / C$$
$$Y^{t+1}\lambda \geq \theta y_i^{t+1}$$
$$X^{t+1}\lambda \leq x_i^{t+1}$$
$$\lambda \geq 0 \qquad \text{(PL2)}$$

$$\left[D_o^t\left(y^{t+1}, x^{t+1}\right)\right]^{-1} = Max\theta, \lambda\theta,$$
$$S / C$$
$$Y^t\lambda \geq \theta y_i^{t+1}$$
$$X^t\lambda \leq x_i^{t+1}$$
$$\lambda \geq 0 \qquad \text{(PL3)}$$

$$\left[D_o^{t+1}\left(y^t, x^t\right)\right]^{-1} = Max\theta, \lambda\theta,$$
$$S / C$$
$$Y^{t+1}\lambda \geq \theta y_i^t$$
$$X^{t+1}\lambda \leq x_i^t$$
$$\lambda \geq 0 \qquad \text{(PL4)}$$

3-3 The TFP estimation by the Malmquist index

For the calculation of the total factor productivity index Malmquist, our study covers 10 of the Mediterranean countries, for a period of 32 years (1980-2012), namely: 10 (4 * 32-2) = 1260 linear programs to solve. On using the DEA-Malmquist model and using Joe ZHU DEAFrontiére of software for each year, a production frontier is constructed that surrounds the observations of each country that will be represented by a unit decision DMU.
Färe, et al. (1994), this index is written equivalently as follows:

$$M_I\left(x_i^{t+1}, y_i^{t+1}, x_i^t, y_i^t\right) = \frac{D_I^{t+1}\left(x_i^{t+1}; y_i^{t+1}\right)}{D_I^t\left(x_i^t; y_i^t\right)}\left[\frac{D_I^t\left(x_i^{t+1}; y_i^{t+1}\right)}{D_I^{t+1}\left(x_i^{t+1}; y_i^{t+1}\right)}\frac{D_I^t\left(x_i^t; y_i^t\right)}{D_I^{t+1}\left(x_i^t; y_i^t\right)}\right]^{\frac{1}{2}}$$

This index can be divided into two independent components one to another. The first term represents the change in the efficiency plan, that is to say, a merger or a distance from the border of the best practices, this term will be represented by ECH_i^t. The second term reflects the change due to of the technological progress that is to say a shift of production to a new frontier of best practices frontier, this term will be represented by TCH_i^t. Finally, the two components of productivity measured by the Malmquist index are defined as follows:

$$ECH_i^t = \frac{D_I^{t+1}\left(x_i^{t+1}; y_i^{t+1}\right)}{D_I^t\left(x_i^t; y_i^t\right)} \qquad TCH_i^t = \left[\frac{D_I^t\left(x_i^{t+1}; y_i^{t+1}\right)}{D_I^{t+1}\left(x_i^{t+1}; y_i^{t+1}\right)} \frac{D_I^t\left(x_i^t; y_i^t\right)}{D_I^{t+1}\left(x_i^t; y_i^t\right)}\right]^{\frac{1}{2}}$$

Dynamic scores of these indices will be measured by DEA using the software DEAFrontiére Joe Zhu (See Appendix B).

4- Conclusion

According to our results, the TFP estimated using the GMM-system method, Morocco achieved a relatively positive TFP evolution, reaching a geometric mean of 0.82 for the period of study. Therefore, with respect to this score, Morocco is situated ahead of Portugal and behind the rest countries of the sample. Morocco has thus evolved TFP that for the last two decades has been positive, except for two years: 1995 and 2007. During these two years, Morocco has experienced hard droughts and TFP has known a negative trend.

As of the average of annual changes scores in terms of technical efficiency, we found that, during the first decade 1980-1990, Morocco has registered a geometric mean of TFP that reached 0,73. This mean is lower than the 0,81 average obtained during the next decade, while for the last considered period of 2000-2012, this raised to 0,90. These show the significant improvement of the TFP evolution.

Similarly, to Morocco, Egypt, Algeria and Tunisia have almost experienced the same fluctuations with a competitive advantage of Tunisia on the rest of the Arab countries. For Portugal, the evolution was positive with the average scores, respectively, for each period, 0,73; 0,70 and 0,78. On the contrary, Italy experienced a decline in terms of the average TFP along the studied period, registering 1,01; 1,00 and 0,99 scores, respectively for each period. For countries such as Spain, Turkey and Greece, the gains in technical efficiency remain positive without any significant improvement. France recorded the most important improvement in the overall sample during the third period (2001-2012), with a 1,18 score.

The resulting estimation of TFP and its two components (technical efficiency and technical change), using the DEA-Malmquist method, showed that, for all countries, productivity gains clearly is originated from the technical progress that is a stimulator of TFP growth due to the close link between TFP improvement and the technical change. Thus, during the period 1980-2012, Morocco has achieved a significant improvement in technical efficiency more than the one related to technical change. Indeed, during our studied period and in terms of the Malmquist index, Morocco has achieved a 0,90 geometric mean of TFP, against an average of 1,00 for the score of technical efficiency, and 0,91 score as the component linked to technical progress. This shows the inadequacy of the contribution of technical progress in improving TFP.

Finally, we clearly showed that the measurement of TFP by the two approaches used in our study is not identical. We stressed that the values of TFP are very different from one method to another. However, we noticed that the score achieved by ranking each country remains the same regardless the used method. For this, the reading of results on the basis of performance comparison seems to be method independent. Figure 1(see Annex c) shows that the geometric means of the period 1980-2012, obtained by the two approaches have the same trends and, therefore, the results of the two approaches are converging. In addition, each method has its advantages and shortcomings, and the choice of the appropriate method depends on the availability and nature of the data (DMU numbers, time, degree of heterogeneity in production technology, proportion of errors measured...).

Endnote

***** Researcher, University Mohamed V, United Nations Avenue, Rabat-Agdal 721, Morocco, e-mail: ali.doumi@gmail.com

References

Arellano, M., and O. Bover., 1995. «Another look at the instrumental variable estimation of error-components models ». Journal of Econometrics 68, pp. 29–51.

Böhm-Bawerk E., 1884. « Histoire critique des théories de l'intérêt du capital » Traduction française en 1902 Paris, édition Giard.

Diewert, W. Erwin., 1976. « Exact and superlative index numbers ». Journal of Econometrics 4 (2), pp. 115–45.

Dovis Marion., 2009. «Formulation et estimation des models de measure de la productivité totale des facteurs: une étude sur un panel d'entreprises turques », Revue d'Economie Politique, vol.119, 6, pp.945-982.

Englander, S. and A. Gurney., 1994 « OECD productivity growth: medium-term trends », OECD Economic Studies, No. 22, Spring, pp. 111-129.

Hayami Y et Vernon R., 1971. «Agricultural Development: An International Perspective», Baltimore: Johns Hopkins press.

Hayami Y et Vernon R., « Agriculture et développement, une approche internationale » Edition INRA, 1998.

Hayami Y et Vernon R., «Induced Innovation Model of Agricultural Development». Ch. 5, pp. 97-112. In C. K. Eicher& J. M. Staatz (Eds.), Agricultural Development in the Third World: 550.Baltimore: John Hopkins University Press, 1990.

Jorgenson, D. W. and Griliches, Z., 1967. «The Explanation of Productivity Change», Review of Economic Studies, 34(3) 1, pp. 249-83.

Kuznetz S., 1966. «Modern Economic Growth: Rate, Structure, and Spread», Yale University Press, New Haven, Connecticut.

Malmquist, S., 1953, « Index Numbers and Indifference Surfaces », Trabajos de Estatistica 4, pp. 209-242.

Malthus Thomas R., 1798, « Essai sur le principe de population ». Edition de 1798 (1), éd. PUF, 1980, 166 p.

Pareto V., « Essai sur la courbe de la répartition de la richesse », Genève, Université de Lausanne, 1896.

Quesnay, F., 1767, « Physiocratie », réédition GF Flammarion, Paris 1991.

Say J.B., 1803. « Traité d'économie politique » réédition Calmann-Lévy, 1972

Schultz T.W., 1964. «Transforming Traditional Agriculture», New Haven: Yale University Press.

Solow R,. 1957. « Technical Change and the Aggregate Production Function », The Review of Economics and Statistics, vol 39, août, pp. 312-320.

Tinbergen, J., 1942. « On the theory of trend movements ». editeurs, North-Holland, pp.82-221.

Turgot, A.-R.-J., 1759. « Réflexions sur la Formation et la Distribution des Richesses », réédition, Paris, 1844.

Zhu, J., 2002. « Quantitative models for performance evaluation and benchmarking: Data Envelopment Analysis with spreadsheets and DEA Excel solver serie ». International series in Operations Research & Management Science, Book 51.

Table 1.Results of the estimation of the production function by the system GMM method

Variables	Coefficient	t	P>|t|
Stock Capital	1.23923	20.67	0.000
Work(Total population employed in agriculture)	-0.1610199	1.93	0.085
NRI/Surface Rainfed Agricultural	0.1008294	2.28	0.048
Constant	-4.525384	-4.00	0.003

M1=0.035, =0.598M2 (M1 and M2 are autocorrelation tests of first and second order residue).
Hansen: chi2 (6) = 7.82Prob>chi2=0.261

Appendix A: Tables of the evolution in total factor productivity in terms of technical efficiency, estimated by method of GMM-system

Year	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Algeria	0,797	0,857	0,839	0,975	0,903	0,907	0,851	1,015	1,109	1,176	1,052	1,018	1,021	1,106	1,093	1,091	1,014
Egypt	0,757	0,746	0,756	0,762	0,760	0,761	0,758	0,799	0,827	0,843	0,845	0,885	0,699	0,700	0,663	0,757	0,819
Spain	0,948	0,875	0,946	0,839	0,959	0,909	0,896	1,005	0,883	0,943	0,989	0,962	1,014	0,970	0,909	0,853	1,063
France	0,854	0,832	0,888	0,866	0,931	0,932	0,914	0,963	1,013	1,015	1,032	1,027	1,114	1,025	1,029	1,061	1,129
Greece	0,843	0,847	0,949	0,960	0,945	0,847	0,935	1,031	1,041	1,047	1,029	1,052	1,047	1,046	1,053	1,054	1,050
Italy	1,118	1,060	1,024	1,155	1,005	1,013	0,999	1,033	0,948	0,972	0,884	0,992	1,022	0,996	0,998	0,991	1,011
Morocco	0,740	0,738	0,752	0,746	0,749	0,751	0,759	0,754	0,765	0,706	0,652	0,752	0,760	0,639	0,878	0,855	0,816
Portugal	0,643	0,641	0,752	0,755	0,752	0,751	0,754	0,758	0,764	0,780	0,677	0,723	0,892	0,820	0,854	0,592	0,582
Tunisia	0,853	0,932	0,971	1,105	1,105	1,043	1,049	1,045	1,047	1,044	1,049	1,066	1,010	1,010	1,011	1,011	1,011
Turkey	1,004	1,008	1,028	1,037	1,030	1,012	1,069	1,011	1,054	1,019	1,027	1,005	1,014	1,042	1,023	1,007	1,043

Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Geometric mean**
Algeria	1,016	1,026	1,010	1,070	1,073	1,091	1,098	1,091	1,061	1,091	1,091	1,097	1,098	1,093	1,092	1,093	1,026
Egypt	0,837	0,946	0,945	0,988	0,981	0,929	0,983	0,986	0,915	0,950	0,973	1,056	1,009	0,956	0,953	0,966	0,857
Spain	1,115	1,059	1,066	1,133	1,128	1,110	1,221	1,107	1,030	1,109	1,086	1,093	1,086	1,118	1,149	0,971	1,012
France	1,143	1,176	1,196	1,189	1,138	1,220	1,090	1,205	1,168	1,113	1,119	1,161	1,236	1,223	1,249	1,269	1,069
Greece	1,042	1,043	1,054	1,053	1,047	1,044	1,026	1,036	1,044	1,032	1,022	1,023	1,017	1,010	1,029	1,111	1,010
Italy	0,999	0,988	1,060	0,960	0,963	0,925	0,890	1,008	0,999	0,958	0,994	1,043	1,072	1,027	1,044	0,993	1,003
Morocco	0,870	0,877	0,871	0,866	0,867	0,875	0,861	0,861	0,894	0,864	0,836	0,855	0,953	0,996	1,022	0,975	0,818
Portugal	0,659	0,655	0,656	0,652	0,652	0,662	0,682	0,706	0,706	0,757	0,764	0,767	0,821	0,865	1,018	1,014	0,737
Tunisia	1,011	1,011	1,011	1,011	1,011	1,011	1,087	1,011	1,109	1,109	1,108	1,109	1,103	1,131	1,109	1,107	1,041
Turkey	1,022	1,074	1,039	1,036	1,065	1,052	1,021	1,022	1,041	1,048	1,067	1,042	1,032	1,056	1,125	1,156	1,040

Appendix B: Scores of productive efficiency by nonparametric approach (Method DEA-Malmquist)

Year		**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
ALG	TFP	1,007	1,027	1,056	1,011	1,038	1,010	1,008	1,016	1,022	1,030	1,043	1,023	1,088
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,007	1,027	1,056	1,011	1,038	1,010	1,008	1,016	1,022	1,030	1,043	1,023	1,088
EGY	TFP	0,689	0,709	0,748	0,723	0,758	0,847	0,899	0,835	0,814	1,022	0,957	0,957	0,904
	TE	0,98	1,03	1,06	0,97	1,04	1,12	1,06	0,93	0,98	1,23	0,95	1,01	0,95
	TP	0,703	0,688	0,706	0,746	0,729	0,756	0,848	0,898	0,831	0,830	1,007	0,948	0,952
SP	TFP	1,043	1,038	1,044	1,041	1,020	1,026	1,037	1,017	1,006	1,006	1,019	1,010	1,034
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,043	1,038	1,044	1,041	1,020	1,026	1,037	1,017	1,006	1,006	1,019	1,010	1,034
FR	TFP	1,020	1,021	1,082	1,018	1,019	1,022	1,021	1,101	1,027	1,027	1,025	1,024	1,177
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,020	1,021	1,082	1,018	1,019	1,022	1,021	1,101	1,027	1,027	1,025	1,024	1,177
GRE	TFP	1,003	1,019	1,015	1,002	1,007	1,012	1,013	1,007	1,009	1,027	1,009	1,005	1,018
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,003	1,019	1,015	1,002	1,007	1,012	1,013	1,007	1,009	1,027	1,009	1,005	1,018
TTA	TFP	1,059	1,032	1,045	1,048	1,007	1,006	1,018	1,015	1,003	0,965	1,007	1,002	1,006
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,96	1,05	1,00	1,00
	TP	1,059	1,032	1,045	1,048	1,007	1,006	1,018	1,015	1,003	1,005	0,959	1,002	1,006
MOR	TFP	0,877	0,881	1,019	1,002	1,002	1,006	1,004	0,998	0,988	1,003	1,001	1,006	0,959
	TE	1,01	1,01	1,14	1,00	1,00	1,00	1,00	0,99	1,00	1,01	1,00	1,00	0,96
	TP	0,868	0,873	0,894	1,002	1,002	1,006	1,004	1,008	0,988	0,993	1,001	1,006	0,999
POR	TFP	0,635	0,720	0,644	0,696	0,666	0,689	0,725	0,649	0,707	0,751	0,717	1,049	1,020
	TE	0,99	1,12	0,90	1,08	0,96	1,04	1,05	0,90	1,08	1,06	0,95	1,40	1,00
	TP	0,642	0,643	0,716	0,644	0,694	0,663	0,691	0,721	0,655	0,709	0,755	0,749	1,020
TUN	TFP	1,032	1,041	1,104	1,026	1,037	1,016	1,022	1,077	1,041	1,045	1,085	1,053	1,034
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,032	1,041	1,104	1,026	1,037	1,016	1,022	1,077	1,041	1,045	1,085	1,053	1,034
TUR	TFP	1,008	1,028	1,037	1,030	1,012	1,069	1,011	1,054	1,019	1,027	1,005	1,014	1,042
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	TP	1,008	1,028	1,037	1,030	1,012	1,069	1,011	1,054	1,019	1,027	1,005	1,014	1,042

ALG : Algeria ; EGY : Egypt ; SP : Spain ; FR : France ; GRE : Greece ; ITA : Italy ; MOR : Morocco ; POR : Portugal ; TUN : Tunisia; TUR : Turkey

Year		**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Geometric mean**
ALG	TFP	1,025	1,045	1,067	1,061	1,039	1,021	1,016	1,026	1,010	1,080	1,071	1,006	1,015	1,046	1,013	1,091	1,022	1,041	1,026	1,034
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,025	1,045	1,067	1,061	1,039	1,021	1,016	1,026	1,010	1,080	1,071	1,006	1,015	1,046	1,013	1,091	1,022	1,041	1,026	1,034
EGY	TFP	0,877	0,941	1,005	1,004	1,036	1,004	1,006	1,027	1,073	1,066	1,031	1,069	1,124	1,018	1,147	1,048	1,055	1,036	1,024	0,942
	TE	0,96	1,07	1,06	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,011
	TP	0,910	0,876	0,946	1,004	1,036	1,004	1,006	1,027	1,073	1,066	1,031	1,069	1,124	1,018	1,147	1,048	1,055	1,036	1,024	0,932
SP	TFP	1,019	1,014	1,027	1,016	1,018	1,009	1,016	1,009	1,019	1,037	1,031	1,020	1,014	1,016	1,022	1,013	1,014	1,012	1,049	1,022
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,019	1,014	1,027	1,016	1,018	1,009	1,016	1,009	1,019	1,037	1,031	1,020	1,014	1,016	1,022	1,013	1,014	1,012	1,049	1,022
FR	TFP	1,026	1,023	1,102	1,103	1,019	1,120	1,120	1,022	1,020	1,177	1,039	1,026	1,014	1,030	1,053	1,026	1,061	1,036	1,052	1,052
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,026	1,023	1,102	1,103	1,019	1,120	1,120	1,022	1,020	1,177	1,039	1,026	1,014	1,030	1,053	1,026	1,061	1,036	1,052	1,052
GRE	TFP	1,012	1,003	1,005	1,010	1,014	1,009	1,002	1,032	1,016	1,000	1,070	1,021	1,041	1,038	1,003	1,012	1,019	1,010	1,006	1,015
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,012	1,003	1,005	1,010	1,014	1,009	1,002	1,032	1,016	1,000	1,070	1,021	1,041	1,038	1,003	1,012	1,019	1,010	1,006	1,015
ITA	TFP	1,003	0,989	0,955	0,940	0,919	0,963	0,896	0,941	0,855	0,857	0,923	0,932	0,935	0,959	0,973	0,956	0,926	0,926	0,869	0,965
	TE	1,00	0,99	0,97	0,99	0,98	1,05	0,93	1,05	0,91	1,01	1,06	1,02	1,00	1,03	1,015	0,983	0,969	1,000	0,937	0,996
	TP	1,003	1,003	0,987	0,954	0,940	0,919	0,963	0,896	0,939	0,847	0,873	0,917	0,931	0,935	0,958	0,973	0,956	0,926	0,927	0,969
MOR	TFP	0,963	0,956	0,961	0,962	0,870	0,868	0,853	0,854	0,854	0,815	0,806	0,805	0,818	0,811	0,816	0,832	0,818	0,823	0,846	0,905
	ET	1,01	0,99	1,00	1,00	0,91	1,00	0,98	1,00	1,00	0,95	0,99	1,00	1,01	0,99	1,012	1,007	0,997	1,004	1,030	0,999
	TP	0,957	0,962	0,962	0,961	0,961	0,869	0,868	0,853	0,854	0,859	0,810	0,806	0,808	0,821	0,807	0,827	0,820	0,819	0,821	0,906
POR	TFP	1,006	1,007	1,026	0,979	0,916	0,968	0,956	0,938	0,966	0,961	0,963	0,979	0,985	0,995	1,000	1,002	1,007	1,011	1,008	0,873
	TE	1,00	1,00	1,00	0,97	0,94	1,06	0,99	0,98	1,03	0,99	1,00	1,02	1,01	1,01	1,005	1,000	1,000	1,000	1,000	1,014
	TP	1,006	1,007	1,026	1,009	0,970	0,916	0,968	0,956	0,938	0,967	0,965	0,958	0,978	0,985	0,995	1,002	1,007	1,011	1,008	0,861
TUN	TFP	1,075	1,007	1,130	1,109	1,082	1,036	1,052	1,039	1,008	1,125	1,060	1,027	1,020	1,013	1,031	1,022	1,027	1,016	1,034	1,047
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,075	1,007	1,130	1,109	1,082	1,036	1,052	1,039	1,008	1,125	1,060	1,027	1,020	1,013	1,031	1,022	1,027	1,016	1,034	1,047
TUR	TFP	1,023	1,007	1,043	1,022	1,074	1,039	1,036	1,065	1,052	1,021	1,011	1,051	1,028	1,077	1,052	1,045	1,069	1,115	1,166	1,042
	TE	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,000	1,000	1,000	1,000	1,000	1,000
	TP	1,023	1,007	1,043	1,022	1,074	1,039	1,036	1,065	1,052	1,021	1,011	1,051	1,028	1,077	1,052	1,045	1,069	1,115	1,166	1,042

TFP : Total Factor Productivity; TE : Technical Efficiency. TP: Technical Progress

Appendix C: Comparison of results obtained by the two methods of analysis

	TFP (Period 1980-2012)			
Country	GMM	Order by Performance	Malmquist index	Order by Performance
Algérie	1,026	4	1,034	4
Égypte	0,857	8	0,942	8
Espagne	1,012	5	1,022	5
France	1,069	1	1,052	1
Grèce	1,010	6	1,015	6
Italie	1,003	7	0,965	7
Maroc	0,817	9	0,905	9
Portugal	0,737	10	0,873	10
Tunisie	1,041	2	1,047	2
Turquie	1,040	3	1,042	3

Graphical of the results obtained by the two methods for analyzing (1980-2012)