Total agricultural productivity in the Mediterranean region using the Malmquist index approach

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Abstract

This study aims to measure the total productivity of agricultural production factors through the calculation of the Malmquist index for six Mediterranean countries during the period 2003-2018. The results indicate that the growth of agricultural productivity in the Mediterranean region during this period by the calculation of the Malmquist index recorded an increase of 13.2%. Much of this productivity growth is driven by technological change rather than a change in technical efficiency or scale. In fact, the technology change increased by 13%, while the technical efficiency change showed a slight increase of 0.2% due to the scale efficiency change of the same percentage. It should be noted that the total productivity of agricultural production factors and the contribution of technical change and scale efficiency have the same trend at the subregional level, but are different at the country level. These results show that the total productivity of agricultural production factors is highly variable between Mediterranean countries and that the overall efficiency gains obtained are largely due to the phenomenon of technological catch-up rather than to gains in scale or efficiency pure.

Keywords: *Agriculture, Total factor productivity, Malmquist index, Efficiency, Mediterranean region.*

1 Introduction

In the Mediterranean basin, the agricultural sector is one of the most important economic sectors which have experienced remarkable growth in the last decades. This growth has been variable from one country to another, forming an increased heterogeneity between them. Indeed, the heterogeneity can be explained by the natural conditions and natural resource endowments but also by the capacity of these countries to integrate into the process of globalization and international trade which promotes the elimination of trade barriers and the liberalization of world markets. The growth of the agricultural sector in the Mediterranean region is explained by several endogenous and exogenous factors of agriculture. For this reason, it is interesting to examine the sources of this growth in agricultural productivity in the Mediterranean region. Indeed, differences in levels of agricultural productivity growth can help identify the underlying factors that positively or negatively affect this productivity (Wiebe *et al.*, 2000). The issue of productivity growth is an important issue in recent

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years as it is considered as the main source of development of the agricultural sector to meet the food needs of the population. For a country that does not achieve agricultural productivity, its growth may suffer deterioration, either in terms of currencies, of internal exchange for industry, which also hinders industrial production (Hayami and Ruttan, 1970; Coelli and Rao, 2003). On the other hand, a country which makes the best use of its available resources for agriculture whether through the know-how or the technicality of their farmers or technological progress can benefit from an advantage on the agro-food balance and on the markets of agricultural export?

Several studies have focused on the issue of productivity, inspired by the concept of efficiency through the approach of parametric and nonparametric data envelope analysis (DEA). Now, the question becomes more detailed and attractive in recent years given the dynamic and evolving aspect reflecting the use of factors of production. The issue of productivity can be analyzed either using measures of Partial Factor Productivity (PFP), such as labor productivity (Gutierrez, 2000; McErlean and Wu, 2003), or measures of Productivity Total Factors (PTF). Sometimes, they used a production function approach (Hayami and Ruttan, 1970; Wiebe *et al.*, 2000), or an index number approach, usually the Tornqvist index (Mukherjee and Kuroda 2003), or a Data Envelope Analysis (DEA) and also the Malmquist approach based on the DEA index (Coelli and Rao, 2003; Ludena *et al.*, 2005). For example, in the United States, a study examined the productivity of agricultural cooperatives using the biennial Malmquist productivity index under varying returns to scale. This index is decomposed into efficiency change and technical change to assess the productivity growth of agricultural cooperatives (Pokharel and Featherstone, 2021). Similarly in the China, a paper aims to study the efficiency of agricultural production of 11 Yangtze River provinces through a combination of Data Envelopment Analysis (DEA) model and Malmquist index to perform dynamic and static analysis of agricultural production efficiency (Pan *et al.*, 2022).

In the Mediterranean region, some work has used the Malmquist index approach in several ways. We can cite the work of Galanopoulos *et al.* (2006), The objective of the article is to analyze the growth of agricultural productivity in the Mediterranean countries on average of the sequential index of total factor productivity (TFP) of Malmquist and, on the other hand, to examine whether this measure converges between these countries (Galanopoulos *et al.*, 2006). Another paper aims to investigate the relationship between trade openness and productivity in the Mediterranean countries agricultural sector. The study basically focuses on analyzing the effects of exports quality on productivity growth at the aggregate farming sector through the estimation of a dynamic production function by the GMM estimator over five groups of agricultural products on a panel of nine South Mediterranean Countries and five European Union Countries for the period 1990 to 2005 (Hassine-Belghith and Ayed-Mouelhi, 2007). In Turkey for example, data envelopment analysis methods and the Malmquist productivity index have been used to measure agricultural production in NUTS1 (Nomenclature of Territorial Units for Statistics) regions (Armagan *et al.*, 2010). For Algeria, a paper aims to analyze the relationship between farm size and farm performance through a bivariate nonparametric regression (Nadaraya-Watson approach) and multivariate quantile regression are used to assess this inverse relationship between two sectors agriculture (the date palm sector and the greenhouse vegetable sector) as dominant activities in the Biskra region of Algeria (Amine Benmehaia, 2022). For Tunisia, an article that aims to analyze the productivity of Tunisian agriculture through an analysis of the own and cross-price elasticity's of different factors of production using a translog production function that provides a practical framework to analyze the response of production to price changes. In addition, a regression approach was used to test the hypotheses that government funded research, development and extension, private and investment, terms of trade and share of irrigated area are important determinants of total factor productivity (TFP) in the agricultural sector (Dhehibi *et al.*, 2014).

The originality of this article comes mainly from the methodological aspect of the integration of two zones (north and south) of the Mediterranean region using panel data for 6 countries over a period of 15 years from 2004-2018, as well as the identification of the productivity characteristics of the agricultural sector through regional and inter-country comparative analysis. Within this conceptual framework, the objective of this article is to analyze the growth of agricultural productivity in Mediterranean countries using the Malmquist indices of total factor productivity (TFP) and its components in order to identify the gaps and sources likely to stimulate the growth of agricultural productivity in the Mediterranean countries. The remainder of the document is organized as follows: Section 2 briefly reviews the literature on the methodological framework for evaluating the concept of effectiveness. Section 3 presents the empirical model with a description of the variables and data used for the construction of the model. In section 4, we report the main econometric results and finally Section 5 summarizes the main findings and conclusions.

2. Methodology

2.1. *Theoretical framework of the Malmquist index*

The Malmquist index is defined as the Output / Input ratio, the total productivity varies both according to the efficiency of the production process and by the type of technology used. Measuring the productivity growth of an industry or a country between two periods amounts to breaking down this notion into two essential components: change in the level of technical efficiency and technological change (Malmquist, 1953). The Malmquist index (M), measures the change in total factor productivity by distinguishing the change in efficiency over time from technical progress (Färe *et al.*, 1994).

The approach to measuring change in productivity over time is based on the use of the Malmquist TFP index (Caves *et al.*, 1982; Färe *et al.*, 1994). The productivity measurement is calculated according to two options: Standard CRS (Constant Return to Scale) and VRS (variable return to scale). The DEA approach which involves the calculation of technical efficiency and scale (TE) and total factor productivity (TFP) which takes into account all the possible inputs and outputs of a Decision Making Unit (DMU) (industry, company, country process). The other option is to use the Malmquist index to quantify the change in the efficiency of an industry over a period of time (Coelli, 1996). All indices are relative to the previous year, so the release begins with the second year. There are five indices for each (DMU) and each period: Change in technical efficiency compared to a CRS technology (effch), technological change (techch), pure change in efficiency compared to VRS technology (pech), change of scale efficiency (sech) and total change in factor productivity (tfpch). Therefore, the results differentiate the farms with productivity growth (tfpch> 1) and decrease in productivity (tfpch <1).

The Malmquist index is a geometric mean of two indices, evaluated against the technologies of period s (the base period) and period t (Färe *et al.*, 1994). A DEA- based, output - oriented Malmquist productivity index measures change (at time t + 1 and t) can be defined according to Färe *et al.* (1992), as follows:

$$M_O(y_s, x_s, y_t, x_t) = = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)}\right] \cdot \left[\frac{d_o^t(y_t, x_t)}{d_o^t(y_s, x_s)}\right]^{1/2} \quad (1)$$

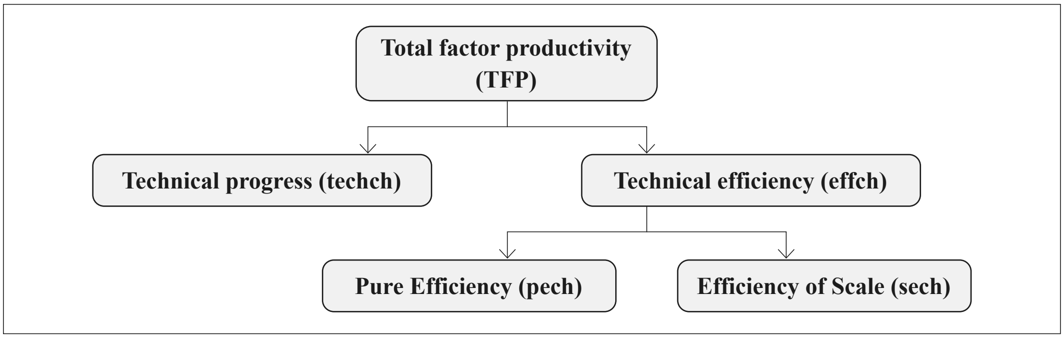
For results or output orientation: there is a growth in productivity when, MO> 1, on the contrary, there is a drop in productivity when, MO <1. Decomposition of the Malmquist index into efficiency change and technological change is carried out according to the following formula:

$$M_O(y_s, x_s, y_t, x_t) = \frac{d_o^t(y_t, x_t)}{d_o^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)}\right] \cdot \left[\frac{d_o^s(y_s, x_s)}{d_o^t(y_s, x_s)}\right]^{1/2} \quad (2)$$

More, the decomposition of the index efficiency change into pure efficiency change:

$$\textit{Pure efficiency change} = \frac{d_{o\,VRS}^t(y_t, x_t)}{d_{o\,VRS}^s(y_s, x_s)} \quad (3)$$

Figure 1 - Decomposition of Total Factor Productivity (TFP).



For the scale efficiency change =

$$\left[\frac{d_{o\,VRS}^{t}(y_t,x_t)/d_{oCRS}^{t}(y_t,x_t)}{d_{O\,VRS}^{t}(y_s,x_s)/d_{oCRS}^{t}(y_s,x_s)}\cdot \frac{d_{o\,VRS}^{s}(y_t,x_t)/d_{oCRS}^{S}(y_t,x_t)}{d_{O\,VRS}^{S}(y_s,x_s)/d_{oCRS}^{S}(y_s,x_s)}\right]^{1/2} \quad (4)$$

To conclude, the decomposition process of total factor productivity according to the Malmquist index approach is summarized in Figure 1.

2.1.2. *Data*

This study has been conducted by constructing a model comprised of one output and seven inputs, involving a set of six Mediterranean countries (Morocco, Algeria, Tunisia, France, Italy and Spain). The period under investigation was 2004-2018, while all required data were taken from the Food and Agriculture Organisation (FAO) database. More specifically, the variables are defined as follows:

Agricultural Production Index *(2014-2016 = 100):* ***GPI*** *- ouput, dependent variable, FAO database.*
Capital Stock *(Consumption of Fixed Capital for Agriculture) Value Local Currency, 2015 price, millions:* ***KS*** *- input, independent varable, FAO database.*
Employment in agriculture *(1000 persons):* ***L*** *- input, indeepndent varable, FAO database.*
Land Use*: arable land in agriculture (1000 ha):* ***LAND*** *- input, independent variable, FAO database.*
Pesticides use in agriculture *(tonnes):* ***PES*** *- input, independent variable, FAO database.*
Fertilizers by nitrogen N *(tonnes):* ***FER-N*** *- input, independent variable, FAO database.*
Fertilizers by potash K2O *(tonnes):* ***FER-P2O5*** *- input, independent variable, FAO database.*
Fertilizers by phosphate P2O5 *(tonnes):* ***FER-K2O*** *- input, independent variable, FAO database.*

The analysis was processed automatically by software STATA.20 for descriptive statistical information; we used a balanced panel data for the period 2004-2018 with around 90 observations for 6 countries in the Mediterranean region (Table 1). The calculation of the Malmquist index and its components is made by software Win4Deep2 software (Version 2.1).

Table 1 - Descriptive statistics for the variables (2004-2018).

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
GPI	90	94.43	13.72	58.02	119.42
KS	90	24138.77	37562.59	671.59	141741.49
L	90	714.82	126.07	434.57	884.00
PES	90	35331.44	30539.24	964	85072
LAND	90	75848.7934	4949.541	15536,00	238174.10
FER-N	90	688494.5	741034.4	4086	2402000
FER-P2O5	90	219237	174862.6	20760	683000
FER-K2O	90	190678	208031.6	4900	889000

Source: Autors, based data of FAOSTAT, 2020.

3. Results and discussion

The results of calculations of Malmquist index and its components are summarized in this section. As calculation results of this index and its components, we calculated measures of change in efficiency (effch), technological change (techch), change in pure efficiency (pech), change in scale efficiency (sech) and total productivity change factor (tfpch) at regional, sub-regional and country levels.

A first chronological reading of the index that the Malmquist index and its components during this period of analysis according to Figure 2 shows that the total productivity of the factors of production and also of the technical efficiency experienced a peak upward period since the years 2005-2006; 2008-2009 and 2015-2016 with a decrease and a stagnation between these periods and a very remarkable decrease for the years 2006-2007 and 2007-2008. This variability is explained on the one hand by the world food price crisis in 2008 and on the other hand by the impacts of climate change on the agricultural sector and the free trade agreements that have been signed by these countries.

3.1. *Regional and sub-regional analysis*

Based on the analysis of the Malmquist index, there is an improvement in the total productivity of production factors in the Mediterranean region and also in the sub-regions, such as the northern region composed by the three countries of the European Union (France, Italy and Spain) and the southern region which also includes the countries of North Africa (Tunisia, Algeria and Morocco). A positive change in the Malmquist index of total factor productivity of 13.2% and also a recorded change in technical efficiency is 13%. A slight increase of 0.2% for technical efficiency under the conditions of constant returns to scale and scale efficiency. On the contrary, a stability of pure technical efficiency in variable returns to scale was recorded for the same period (Table 2).

At the sub-regional level, the results are a little different with an improved evolution for the southern Mediterranean region for a total factor productivity of 22.8%, a technical efficiency of 21.9% and a slight evolution of the technical efficiency and scale efficiency of 0.7%. On the other hand, the northern Mediterranean region, a positive and less significant evolution for the same types of efficiency parameters, we recorded: total productivity of the factor of production of 14.5%, technical efficiency of 14.2% and a slight evolution concerning the technical efficiency and the efficiency scale of 0.3%. For pure technical efficiency, no change recorded at the sub-regional scale (Table 2).

The increase in the Malmquist index of total factor productivity is explained by a significant contribution of the technical efficiency index as well as the scale efficiency index. This index and its components such as the technical efficiency

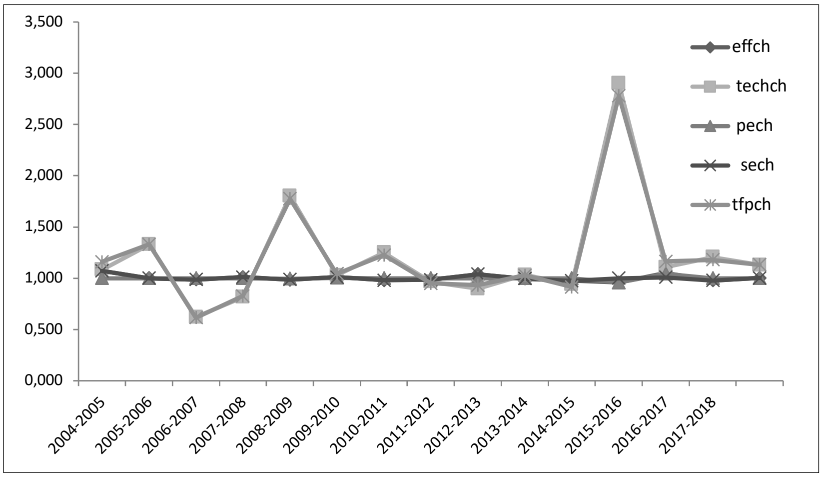


Figure 2 - Trend of the total productivity Malmquist index.

Table 2 - Malmquist indices for the period 2004-2018 in the Mediterranean region.

Sub-region/region	*effch*	*techch*	*pech*	*sech*	*tfpch*
Northern of the Mediterranean region	1.003	1.142	1.000	1.003	1.145
South of the Mediterranean region	1.007	1.219	1.000	1.007	1.228
Mediterranean region	1.002	1.130	1.000	1.002	1.132

Efficiency change (effch). Technological change (techch). Pure efficiency change (pech). Scale efficiency change (sech). Total factor productivity change (tfpch).
Source: Own elaboration.

index, confirm that these countries of the Mediterranean region have experienced technological change and are well engaged in the process of modernization of the agricultural sector. This attempt of insertion in the technological modernization is thwarted by structural difficulties in the strategy of the reform of the existing agricultural exploitations those which show the stability of the index of the pure technical efficiency during the reference period.

3.2. *Country analysis*

Table 3 summarizes the main results of the empirical analysis on the Malmquist index of factor productivity. The evolution of this total productivity of production factors during this period showed an average growth of 13.2% in agricultural productivity in the Mediterranean countries. Tunisia (45%), followed by Spain (42.5%) and Morocco (41.3%), are the main countries with an annual productivity growth rate above 1% and all the other countries of the sample show a loss of productivity with an annual productivity growth rate of less than 1%, such as Algeria, France and Italy which respectively recorded a loss of productivity during the reference period of 9.7%, 16.2% and 4.9%. Part of this productivity gain is relatively explained in these three countries by a change in technological efficiency. For Tunisia, the productivity gain of (14.5%) is entirely due to technical progress. On the other hand, Spain showed a variation in technical progress of 43.2% which exceeds the gain in productivity which is 42.5%, this small difference is explained by the low technical efficiency recorded which of the order 0.5% during the reference period. For Morocco, the productivity gain of (41.3%) is explained by a technological change of 40.5% but also by a change in technical efficiency under the conditions of constant returns to scale, which is due to the change in scale efficiency of 0.6%. For the rest of the countries (Algeria, France and Italy), the loss of total production factor productivity is mainly due to low technical progress and technical inefficiency except Algeria which showed a technical and scale efficiency of 1.5 %; but it is a country that has failed to achieve factor productivity growth.

Table 3 - Malmquist indices by countries for the period 2004-2018.

Countries	*effch*	*techch*	*pech*	*sech*	*tfpch*
Algeria	1.015	0.890	1.000	1.015	0.903
France	0.995	0.842	1.000	0.995	0.838
Italy	1.000	0.951	1.000	1.000	0.951
Morocco	1.006	1.405	1.000	1.006	1.413
Spain	0.995	1.432	1.000	0.995	1.425
Tunisia	1.000	1.45	1.000	1.000	1.450
Mediterranean region	1.002	1.130	1.000	1.002	1.132

Efficiency change (effch). Technological change (techch). Pure efficiency change (pech). Scale efficiency change (sech). Total factor productivity change (tfpch).
Source: Own elaboration.

Table 4 - Comparative of the Malmquist index (adopted model (a) against classic model (c)).

Countries	*Effch (rang)*		*techch(rang)*		*pech(rang)*		*sech(rang)*		*tfpch(rang)*	
	(a)	*(c)*	*(a)*	*(c)*	*(a)*	*(c)*	*(a)*	*(c)*	*(a)*	*(c)*
Algeria	1.015 (1)	1.003 (3)	0.890(5)	0.996(6)	1. 0	1.0	1.015(1)	1.003(3)	0.903(5)	0.999(6)
France	0.995(4)	0.995(5)	0.842(6)	1.021(5)	1.0	1.002(1)	0.995(5)	0.993(6)	0.838(6)	1.016(5)
Italy	1.000(3)	1.005(1)	0.951(4)	1.024(4)	1.0	1.0	1.000(3)	1.005(1)	0.951(4)	1.029(4)
Morocco	1.006(2)	1.004(2)	1.405(3)	1.260(3)	1.0	1.0	1.006(2)	1.004(2)	1.413(3)	1.265(3)
Spain	0.995(4)	0.997(4)	1.432(2)	1.276(2)	1.0	0.995(5)	0.995(6)	1.002(4)	1.425(2)	1.272(1)
Tunisia	1.000(3)	0.991(3)	1.45(1)	1.280(1)	1.0	0.991(6)	1.000(4)	1.000(5)	1.450(1)	1.270(2)
Region	1.000	0.999	1.429	1.135	1.0	0.998	1.000	1.000	1.429	1.134

(a): Estimation of the Malmquist index according to the production function model used.
(c): Estimation of the Malmquist index according to the classical production function model.

Can the calculation of the Malmquist index of factor productivity according to the neoclassical production function theory give another trend or interpretations of the evolution of efficiency for the reference period for the countries of the Mediterranean region?

To answer this question, the calculation of the Malmquist index according to a neoclassical production function is formed by an output variable the index of agricultural production and as input variables the Stock of Capital (KS), the Employment (L) in Agriculture and Land Use (LAND). Therefore, the purpose of this simplification by eliminating all crop management inputs such as fertilization and pesticide use is to know the sources of change and the production model adopted by some countries. The calculation and classification of the rank of the Malmquist index and its components are presented in Table 4. By comparing the values between the adopted model and the classical model, we observe a regression of the factor productivity index for the three countries (Tunisia, Spain and Morocco), this regression due to technical inefficiency (case of Tunisia), and pure efficiency (case of Tunisia and Morocco). The most remarkable according to the classic model, an increase in total factor productivity for France and Italy 1.6% and 2.9% respectively as a result of the technical progress recorded for technical efficiency and of scale for Italy and pure efficiency for France. Similarly, the change in rank of certain Malmquist indices and its components reflects not only the evolution or deterioration of efficiency but also the sources of productivity growth and the nature of the change (Table 4).

Indeed, the loss of factor productivity gain specifically for Tunisia and Morocco following the elimination of input variables linked to the management of the use of fertilizers and pesticides clearly shows that agriculture in the south of the Mediterranean, particularly in North Africa, is very dependent on organic inputs and pesticides in the absence of strong instructions against the massive use of these inputs.

In the other northern shore of the Mediterranean region, the existence of clear policies and strong obligations under Common Agricultural Policy (CAP) laws limits the use of these inputs, especially pesticides. In this case for the north of the Mediterranean region, the gain in productivity is due to technical progress and technical efficiency which contribute to the change of scale through agricultural investment and the dynamics of European agriculture, on the other hand go. In the southern part of the Mediterranean, the gain in factor productivity according to the Malmquist index comes not only from technical progress but from farming techniques and mastery of fertilization and the use of pesticides. Indeed, to maintain this productivity, some countries such as Tunisia, for example, resort to an excessive use of these organic, mineral and sanitary inputs to remedy soil fertility problems and diseases. The gain in productivity is therefore explained by the technical skills and know-how of the farmers of these countries rather than by technological progress.

3.3. *Analysis of the Malmquist index by sub-period*

To deepen the interpretations of the Malmquist index and its components calculated by the agricultural production model adopted, an analysis by sub-periods for each country of the Mediterranean region is carried out. The first sub-period is extended between 2004 and 2011 and the second sub-period is extended between 2011 and 2018 (Table 5). According to Table 5, the calculation of the Malmquist index and its components calculated by sub-periods for each country in the Mediterranean region provides information on the evolution of the efficiency index over time. Indeed, the countries that achieved a gain in factor productivity over the entire reference period (2011-2018), some of them experienced a loss between the first and second sub-periods. Example for the case of Tunisia which experienced a deterioration in total factor productivity of more than 5%, and this result is expected and explained by the 2011 revolution which was marked by political and socio-economic instability . Morocco also experienced a slight loss in total factor productivity of more than 2% due to inefficiency and can be explained by the political and socio-economic orientation in terms of employment towards the encouragement of the manufacturing sector. tourism for the benefit of the agricultural sector taking advantage of the marked security instability in Tunisia during this period. On the contrary, Spain achieved a gain in total factor productivity between the sub-periods by a positive evolution of progress and technical efficiency with an evolution of scale efficiency. The rest of the countries, with the exception of Italy, did not achieve any gain in total factor productivity despite changes in the Malmquist index and some of its components. While Italy, it experienced a gain in total productivity for the second period (2011-2018) which is characterized by a positive evolution of technical progress of 1.4%.

In conclusion, the analysis of factor productivity by the Malmquist index during the reference period (2004-2018) for the agricultural sector of the Mediterranean region for the six countries (Algeria, Tunisia, Morocco, France, Italy and Spain) showed several characteristics regarding the evolution of efficiency over time. The gain in factor productivity recorded at the regional level showed the general trend at the regional level. While the calculation of the Malmquist index and its components by sub-region, by country and by sub-period justified in detail the nature and sources of this evolution, whether it is a gain or a loss of factor productivity. Most of the positive gains recorded for factor productivity are explained by a change in efficiency by a positive

Table 5 - Malmquist indices calculated for the sub-period 2004-2018 by countries.

Countries	*Period*	*effch*	*techch*	*pech*	*sech*	*tfpch*
Algeria	2004-2011	**1.030**	0.834	1.000	**1.030**	0.859
	2011-2018	1.000	0.950	1.000	1.000	0.950
France	2004-2011	0.998	0.735	1.000	0.997	0.733
	2011-2018	0.993	0.948	1.000	0.993	0.942
Italy	2004-2011	1.000	0.892	1.000	1.000	0.892
	2011-2018	1.000	**1.014**	1.000	1.000	**1.014**
Morocco	2004-2011	**1.033**	**1.379**	1.000	**1.033**	**1.425**
	2011-2018	0.979	**1.431**	1.000	0.979	**1.401**
Spain	2004-2011	0.980	**1.414**	1.000	0.980	**1.386**
	2011-2018	**1.010**	**1.451**	1.000	**1.010**	**1.466**
Tunisia	2004-2011	1.000	**1.476**	1.000	1.000	**1.476**
	2011-2018	1.000	**1.424**	1.000	1.000	**1.424**

Source: Own elaboration: Efficiency change (effch). Technological change (techch). Pure efficiency change (pech). Scale efficiency change (sech). Total factor productivity change (tfpch).

change in technical progress and technical efficiency by a change in efficiency of scale. These results are similar to other results found in works on the calculation of the Malmquist index and its components in the Mediterranean region. As an example, Galanopoulos *et al.* (2006) studied the growth of agricultural productivity in the Mediterranean region for Mediterranean countries in the Union and outside the European Union and also for countries in the Middle East and North Africa (MENA) for the period 1961 to 2002. Its results showed the same trend compared to our results found at the regional level with a productivity gain of 0.7% in productivity and a positive gain in factor productivity for countries such as Tunisia by 0.5%, Spain by 1% and Morocco by 1.7%, while Algeria suffered a loss of factor productivity by 0.5%. These recorded productivity growth rates are entirely attributable to improving technological progress (Galanopoulos *et al.*, 2006). Similarly, Kaliji *et al.* (2013) found that changes in the factor productivity of Iranian wheat production were more affected by technical changes in some provinces, while in others they were due to changes in technical efficiency. This work is more in line with the results of Chaudhary (2012) who concluded that the contribution of technical change was greater than that of efficiency change when compared to overall productivity changes in Indian agriculture. Headey *et al.* (2010) also showed that agricultural technical change was more important than efficiency change for countries in the Middle East and North Africa. Similarly, with similar data, Coelli and Rao (2005) study the period 1980-2000 and report an annual factor productivity growth for Egyptian agriculture of 1.2% due exclusively to technical change, which is consistent with our results. Moreover, Coelli and Rao (2005) compared the decomposition of total factor productivity with other neighboring countries, i.e. in Algeria, Tunisia and Iran, the contribution of change in efficiency to the evolution of factor productivity played an important role, while in Iraq and Syria, the results showed a decline in factor productivity following a decline in technical efficiency.

Finally, the results of the calculation of the Malmquist index and its components during the reference period (2004-2018) for the agricultural sector in the Mediterranean region for the six countries (Algeria, Tunisia, Morocco, France, Italy and Spain) proves the evolution of these indices and most of the Mediterranean countries have drawn technological innovations adopted in their agricultural sectors. These technological innovations do not manifest only through machinery and technology, they can be traditional technological innovations such as the use of new varieties, the use of fertilizers or other types of innovations such as better information and better training. farmers to adopt advanced techniques of management and use of inputs such as irrigation techniques, planting methods, use of micronutrients and mainly the know-how acquired by farmers in developing countries.

4. Conclusion and recommendations

This article studied the growth of agricultural productivity across six countries in the northern and southern parts of the Mediterranean region (Algeria, Tunisia, Morocco, France, Italy and Spain) during the reference period (2004-2018). For this purpose, the Malmquist approach and its components was used to calculate the total factor productivity indices. A gain in factor productivity is recorded at the level of the region and also at the level of certain countries such as (Tunisia, Morocco and Spain). Much of this gain in total factor productivity is explained by a change in technological efficiency rather than a change in technical efficiency. Indeed, change in technical efficiency was somewhat modest due to small change in efficiency scale and stagnation in pure efficiency.

This model of agricultural productivity growth finds its explanations in the agricultural policies adopted in particular for Tunisia. The introduction of the technological package of the green revolution can be interpreted as the most important technological innovation that has taken place in Tunisian agriculture during the last thirty years. This technology, combined with irrigation and the intensive use of chemical fertilizers, herbicides and agricultural equipment in various crops, which has been the main source of agricultural growth in Tunisia. It can be deduced that during the Green Revolution the adoption of technology was not uniform in the Mediterranean region, but the diffusion of the technology gradually spread, it allowed the underperforming countries of the gap with the more efficient. However, this process was not strong enough to generate a complete catch-up, given that in the long term, for the whole period, the frontier shifts was greater than the movements towards the frontier. This technological catch-up in Tunisia was not accompanied by a significant change of scale given the fact that the possibilities for expanding arable land are limited. Agrarian structures are still fragile marked by fragmentation, concentration and untitled land. Structural policies in Tunisia have not had the desired effect despite the important measures adopted to improve the institutional environment.

An agricultural policy reform in the Mediterranean region and in particular in Tunisia must be well developed to remedy these shortcomings and increase the productivity of the sector. A model of agricultural growth requires a diversified policy with applicable instruments. This policy must call for structural strategies for the sustainable management of natural resources taking into account climate change and the resumption of the role of the State as being responsible for the execution of this adequate management of natural and land inputs as well as encouragement of agricultural investment. This responsibility must also establish internal policies aimed at the social and economic dimension in fragile rural areas and external policies encouraging export and trade through the modernization of farms to strengthen the place of Tunisian agriculture on the international market.

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