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The Effect of Trade Liberalization on the Sustainability of Agricultural Sectors in Egypt and Tunisia: A New Framework Based on TFP Growth Structure

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Introduction

The impact of agricultural trade liberalization on economic growth, poverty and inequality in developing countries has always been an important issue in the debate concerning international trade and development policy analysis. Several international development agencies and organizations involved in trade policy and poverty reduction have recently allocated substantial resources to analyse this issue (Ali and Talukder 2010).

In developing countries of the MENA (Middle East and North Africa) region, agricultural trade reforms could affect agriculture productivity in different ways according to the level of farmers' involvement in international trade. A number of studies have been carried out in the field of agricultural trade liberalization and its impacts; but the combined focus on policy measures, agricultural growth, food security and farmers' income distribution has not been clearly addressed.

Current poverty and vulnerability in the MENA dryland region has been exacerbated by low productivity of natural resources, including less

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favourable agro-climatic conditions. The consequent marginal status of these areas has led, most of the time, to their overall neglect reflected through permanent under-investment and generally inappropriate development interventions. Therefore, increasing agriculture productivity is considered as one of the most fundamental ways to ensure food security and promote farmers' income mainly in these marginalized areas.

Despite the fact that agricultural productivity in the MENA has been recently given extensive attention, few studies have examined the agricultural growth sustainability in these countries. Sustainability in agricultural growth is highly important to investigate future development of agricultural sectors in MENA countries. Moreover, whether trade openness and domestic investment (public and private) policy which, among other factors, are used to promote agricultural Total Factor Productivity (TFP) growth could also play a great role in the sustainability of such growth is rarely examined.

Sustainability of TFP is challenged by water shortages and climate change, suggesting that increasing irrigation to improve agricultural productivity is unfeasible. Drine (2011) analysed the impact of climate variables on agricultural productivity in the MENA region. His results suggest that lower precipitation, heat waves and drought are the main causes for decreasing agricultural productivity in the region. Thus, other pathways to increase TFP growth have to be investigated in order to increase agricultural production (Al-Said et al. 2012, Molden et al. 2010).

Analysis of TFP growth is the main focus of this paper, with Tunisia and Egypt serving as study countries. We collected data for these countries for the period 1961-2012, which we used to determine the factors that significantly affect agricultural productivity growth. Tunisia and Egypt represent countries that follow the classical transition from agriculture to industry (Kuznets 1955), in contrast with most of the oil-rich countries in the West Asia and North Africa region which have undergone some form of structural transition between traditional manufacturing sectors and a global energy sector stemming from oil abundance (Acar and Dogruel 2012).

TFP growth stems from two sources, technical efficiency and technical change (Hong et al. 2010). TFP growth pattern could be defined as the trade-off between these two sources. Although different growth patterns determine differentiated growth in TFP, the weight between the two sources of growth should be assessed and coordinated to achieve optimal TFP growth.

Under a certain level of technology, improvement of technical efficiency is limited; holding technical efficiency constant, incentive of technology research and development is lacking, and applicability of new technology is restrained. This generally describes the situation in developing countries, a category that the majority of MENA countries fit into. Thus, the sustainability of TFP growth can suffer from over-dependency on either one of these sources. Indeed, it is the structure of TFP growth that embodies and decides the sustainability of the agricultural sector.

The remainder of this paper is divided into five major sections. Section 2 provides a literature review on the empirical approaches used to measure agricultural productivity in Tunisia and Egypt. Section 3 presents the methodologies used to measure TFP, and discusses the data used in Tunisian and Egyptian TFP growth. Section 4 presents results obtained from analysis of outputs, inputs and TFP measurements, and then describes and summarizes the key findings of the TFP determinants. Finally, Section 5 presents conclusions and policy implications.

8.1 Literature Review on TFP Growth in the MENA Region

Food insecurity in the MENA region is a recurring challenge related to several critical factors including scarcity of water and limited area for agricultural production. According to World Bank (2010), the MENA is the world's most water-scarce region. The region has a total area of about 14 million km^2, of which about 87% is desert. Agriculture in the region is highly climate-sensitive, while a large share of its population and economic activities are located in urban coastal zones. Furthermore, most people are city dwellers, not desert pastoralists.

The region annual water demand exceeds its supply. Rainfall is decreasing, river flows are shrinking, and groundwater resources are being depleted. Accordingly, availability of water and subsequent agricultural production are expected to diminish (UNDP 2009). By 2025, 80-100 million people in the MENA region will be exposed to water stress (Warren et al. 2006). By 2050 water availability per capita will fall by 50% and there is a high potential for food crises due to increasing demand (population) and declining supply factors (precipitation and yields). In addition, growing competition for water is expected to reduce the share of agriculture in total GDP to 50% by 2050.

The region needs to deal with food production inefficiencies which mainly result from inappropriate farming methods, and low levels of farmers' technical skills and education. Limited opportunities for financing and lending as well as inappropriate agricultural policies have resulted in an overall decline of agricultural production in many countries. On the other hand, harsher living conditions in rural areas, due to the above-mentioned factors including lack of agricultural and rural development strategies, are likely to lead to more rural-urban migration.

The degradation of agriculture is likely to increase unemployment in some countries where farm workers constitute about 30% of the total labour force. Gender inequality is likely to increase since the share of women in the agricultural labour force is relatively high in many countries of the region (for example, women represent 58% of the total unskilled workers in the agricultural sector in Tunisia). On the other hand, improving agricultural productivity will help to increase farmers' income and overall food supply, enhance farmers' resilience to expected future changes, and lower the reliance of the region on food importation.

The overall growth performance of the MENA region over the period 1960-2000 has been both mixed and characterized by a higher degree of volatility compared to other regions in the world (Esfahani 2006, Makdisi et al. 2006). In their review of overall economic growth patterns in the MENA region, Makdisi et al. (2006) found that capital is a less efficient factor, trade openness is less beneficial to growth, institutions are less efficient compared to the rest of the world, and the impact of adverse external shocks is more pronounced. Stock of human capital in the region is also modest due to the quality of education systems geared to the needs of the public sector (Makdisi et al. 2006; Pissarides and Véganzonès-Varoudakis 2006). Accordingly, MENA countries have failed to deploy human capital efficiently for economic growth (Pissarides and Véganzonès-Varoudakis 2006).

This low economic growth performance in MENA countries is particularly significant for their agricultural sectors. The MENA region is considered as among the driest in the world, while its population continues to grow and is projected to double over the next 40 years (CIESIN 2002). One of the major challenges in the MENA region is thus to increase agricultural production for the rapidly growing population. According to the Food and Agricultural Organization, water will be a crucial constraint in this respect. In fact, in MENA countries, renewable groundwater and surface water supply are limited while demand for water is growing rapidly (Hellegers et al. 2013). A high proportion of agricultural production in the MENA region currently depends on unsustainably high groundwater use (Hellegers et al. 2013). Some countries, including Saudi Arabia, are already exploring the possibilities for making groundwater extraction sustainable in the future, for instance by reducing the area of land under wheat and by importing wheat (Hellegers et al. 2013).

Few studies in the literature have analysed TFP growth of agricultural sectors in MENA countries. Belloumi and Matoussi (2009) investigated the patterns of agricultural productivity growth in 16 MENA countries during the period 1970-2000. They used a nonparametric, output-based Malmquist index to calculate and decompose the agricultural TFP in the selected countries. Their results show that, on average, agricultural productivity growth in the region increased at an annual rate of 1% during the whole period (Belloumi and Matoussi 2009). They also show that technical change is the main source for this growth and that agricultural productivity in the region is decreasing, especially in countries suffering from political conflicts and wars.

Ben Jemaa and Dhif (2005) used a meta-frontier approach to provide calculations of TFP growth, technical efficiency and input productivity for 12 MENA countries and their potential European competitors. In that study, the authors corrected the technical efficiency scores by a coefficient of technical gap since technologies differ between the regions studied. Their results show technological gap to be the main factor favouring the set of European actors included in the study. However, they observed that a catch-up process is underway between the two regions, in terms of technical efficiency. Ben Jemaa and Dhif (2005) also found that literacy rate, irrigated area and agricultural exports (trade openness) have a considerable effect on efficiency alleviation in the MENA region. Dhehibi and Rached (2010) investigated the agricultural production structure and the sources of TFP growth of the Tunisian agricultural sector between 1961 and 2007. The main aim of the study was to analyse the impact of the agricultural sector adjustment programme on Tunisian agricultural total factor productivity. The authors used a Törnqvist index approach. Their results show that the output growth in Tunisian agriculture was volatile over the whole period of analysis. They also found that the agricultural output growth increased in the 1961-1970, 1971-1980 and 2001-2007 periods, but decreased during the 1981-1990 and 1991-2000 periods. Over the whole period, livestock, capital and intermediate inputs were the most important contributors to the output growth of Tunisian agriculture.

8.2 Measuring Agricultural Productivity: An Application of the Törnqvist-Theil Index

8.2.1 Theoretical Framework

There are basically two approaches to measure the TFP growth: the frontier and non-frontier approaches[2] (Figure 8.1). Each of these approaches is further divided into parametric and non-parametric techniques. In the frontier approach, best observed combinations of inputs-outputs are estimated and compared to the rest of the sample observations (cross sectional or time series). Frontier refers to an unobservable function that is said to represent the best practice function (Mahadevan 2004). Observations corresponding to the best obtainable output given constant inputs and prices levels are identified in order to compare the rest of the observations to the best obtainable output.[3] TFP growth as obtained from the frontier approach consists of outward shifts of the production function resulting from technological progress, and from technical efficiency improvement, which are related to enhancements in farmers' technical skills through time.

The non-frontier approach assumes that firms are technically efficient, and therefore technological progress determines shift in the production function or TFP growth (Mahadevan 2004). Absence of technical efficiency in the non-frontier approach is justified by Kalirajan and Shand (1994) by arguing that in the long-run firms learn management practices to adjust costs and inputs, thereby approaching higher and higher levels of efficiency. The non-parametric frontier approach, which is typically statistical, evaluates firms to an average producer, and hence is characterized as a central tendency approach (Mahadevan 2004).

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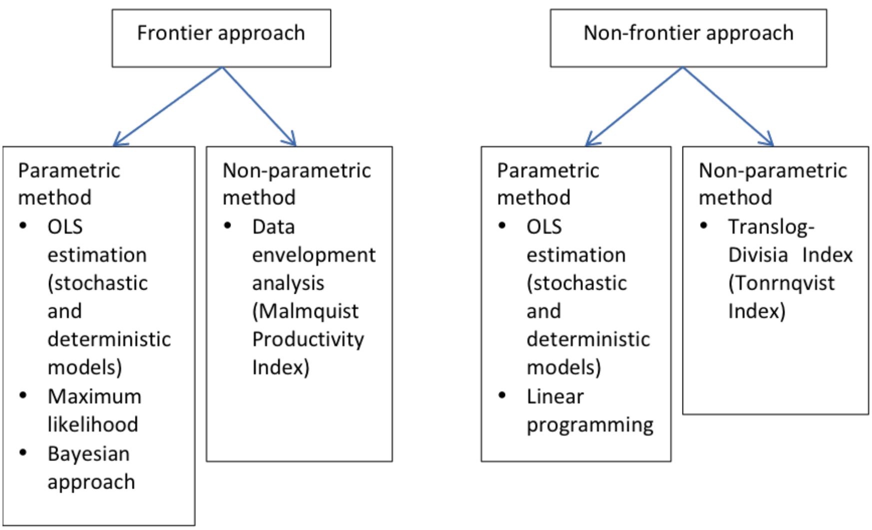
[2] Each of these approaches is further divided into parametric and non-parametric techniques. Parametric estimations need the specification of a functional form for the frontier and parameters are estimated through econometric techniques using sample data and outputs. One important implication of this issue is that the accuracy of the derived estimates is sensitive to the specified functional form. In contrast, this latter point is the strength of the non-parametric methods (such as data envelopment analysis DEA, or other mathematical programming methods), which are parameter-free and do not assume any functional form. However, one shortcoming of non-parametric approaches is that no direct statistical tests can be carried out to validate the estimates.

[3] The frontier approach is different from the parametric non-frontier approach where the average function is estimated by the ordinary least square regression as the line of best fit through the sample data (Kathuria et al. 2013).

Frontier and non-frontier approaches can be estimated by parametric and non-parametric methods (Figure 8.1). The parametric method mainly uses econometrics. In this research we used non-parametric methods for the frontier and non-frontier approaches in a complementary way to estimate TFP. The main reason for using non-parametric methods is the ability of such methods to provide detailed information on the contribution of each of the inputs to output growth (Mahadevan 2004), thus shedding light on the weight of each production input in output growth. In addition, non-parametric approaches allow for inter-country comparison studies, which in our case becomes relevant to compare TFP growth in Egypt and Tunisia.

Non-parametric index number methods allow estimating TFP based on simple pre-defined formulas, and without need of econometric estimation. A common feature of the index number is that the empirical estimation of different indexes is based on different weighting methods of inputs and outputs. In most empirical studies regarding TFP measurement in the agricultural sector, the Malmquist and Törnqvist indexes have been used (Mahadevan 2004).

Figure 8.1. Approaches to Measuring Total Factor Productivity



Source: authors' elaboration adapted from Mahadevan (2004).

The increased use of inputs, to a certain extent, allows the agricultural sector to move along the production surface. The use of modern inputs may also induce an upward shift in the production function, to the extent that a technological change is embodied in them. TFP measures the extent of increase in the total output, which is not accounted for by increases in the total inputs. TFP is defined as the ratio of an index of aggregate output to an index of aggregate input. One of the most defensible methods of aggregation in productivity measurement is Divisia aggregation. Divisia indices have two important attractive properties: (i) they satisfy the time reversal and factor reversal tests for index numbers, and (ii) it is a discrete of the components, so that aggregate could be obtained by the aggregation of subaggregates. For discrete data, the most commonly used approximation to the (continuous) Divisia index is the Törnqvist approximation.

In this paper, we have used the Törnqvist-Theil index to estimate TFP across countries. This index was used to construct both the aggregate output and input indexes. According to this approach, growth in total factor productivity (TFP) is considered as equivalent to growth in technical change.[4] The Törnqvist output, input and TFP index in logarithm form can be expressed as follows:

Output index:

$$Ln\left(\frac{Q_t}{Q_{t-1}}\right) = {}^1/_2 \; \Sigma_j\left(R_{j,t} + R_{j,t-1}\right)Ln\left(\frac{Q_{j,t}}{Q_{j,t-1}}\right) \tag{1}$$

Input index:

$$Ln\left(\frac{X_t}{X_{t-1}}\right) = {}^1/_2 \; \Sigma_i\left(S_{i,t} + S_{i,t-1}\right)Ln\left(\frac{X_{i,t}}{X_{i,t-1}}\right) \tag{2}$$

TFP index:

$$Ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = Ln\left(\frac{Q_t}{Q_{t-1}}\right) - \; Ln\left(\frac{X_t}{X_{t-1}}\right) \tag{3}$$

Where:

- $R_{j,t}$ is the share of output (*j*) in total revenue in time (*t*)
- $Q_{j,t}$ is the output (*j*) in time (*t*)
- $S_{i,t}$ is the share of input (*i*) in total input cost
- $X_{i,t}$ is the input (*i*) in time (*t*)

The TFP Törnqvist-Theil index measures TFP changes by calculating the weighted differences in the growth rates of outputs and inputs. The growth rates are in log ratio form, and the weights are revenue and cost shares for

[4] Further explanations of the theoretical properties and issues in measurement of productivity through the Törnqvist Index can be found in Diewert (1978, 1980), Christensen (1975), Capalbo and Antle (1988) and Coelli et al. (2005).

outputs and inputs, respectively. The TFP index as defined in the last equation can be used as an approximation of technological progress, assuming that producers behave competitively, production technology is input-output separable, and there is no technical inefficiency (Antle and Capalbo 1988).

8.2.2 Data and Variables Specification

The FAO's annual time series (from 1961 to 2011) for all crops and livestock products, land areas, labour, machinery, animal capital and fertilizer consumption were used to build databases representing agricultural outputs and inputs, which in turn were the sources to construct the Törnqvist index and its components for the two selected countries. Specifically, the FAO sourced data on Total Agricultural Output (value); Seeds (in quantity and value); Machinery (in quantity and value); Pesticides (in quantity and value); Feed (in quantity and value); Capital stock (in quantity and value); and Natural resources (water/land) (in quantity and value). These data were complemented with labour data (in quantity and value) collected from Egyptian and Tunisian national statistical institutes. Finally, we also collected data on the human development index from UNDP. Exhaustive lists of collected variables as well as their sources are presented in annexes (Tables 8.1 and 8.2).

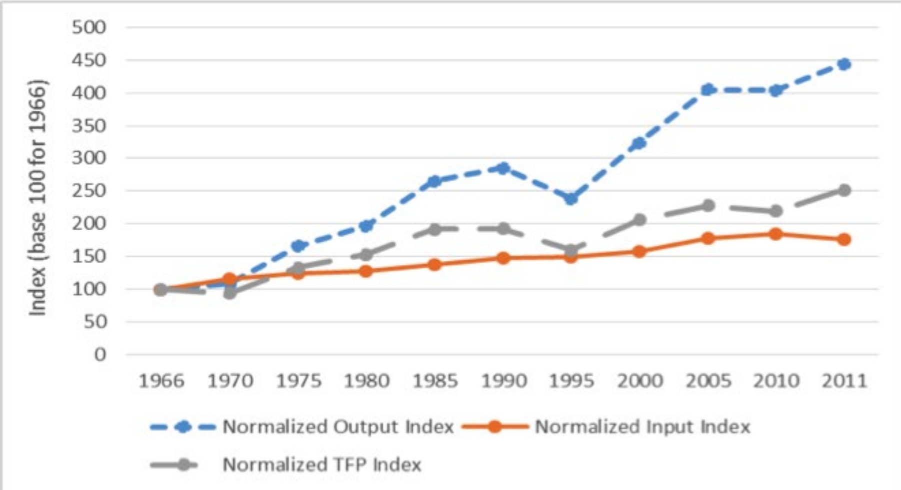
8.3 Empirical Findings and General Discussion

This section presents the results of the calculations of the Törnqvist productivity index for the Tunisian and Egyptian agricultural sectors between 1962 and 2012.

8.3.1 Outputs, Inputs and TFP Indexes

Based on equations 1-3, the annual average growth rates for the Tunisian agriculture sector in the total output index (TOI), total input index (TII) and total factor productivity index (TFPI) between 1966 and 2011 are presented in Figure 8.2 and Table 8.2. The Törnqvist TFPI (Figure 8.2 and Table 8.1) shows an important fluctuation over the analysis period. This fluctuating trend is mainly due to the fluctuation of the output index, which is primarily explained by the variability of rainfed agriculture in Tunisia due to highly variability in climate conditions over the years.

Figure 8.2. Törnqvist Output, Inputs, and Total Factors Productivity Indexes, for the Tunisian Agricultural Sector (1966-2011)



Source: authors' elaboration (2014).

Figure 8.2 and Table 8.1 also show an increasing trend of the output, inputs and TFP indexes in Tunisia. This clearly indicates that the technical change in both countries is not only affecting the TFP itself, but has an influence on the sustainability of TFP growth. However, these values lead us to a further analysis in order to investigate the different components of TFP growth and attribute specific shares to the different growth sources.

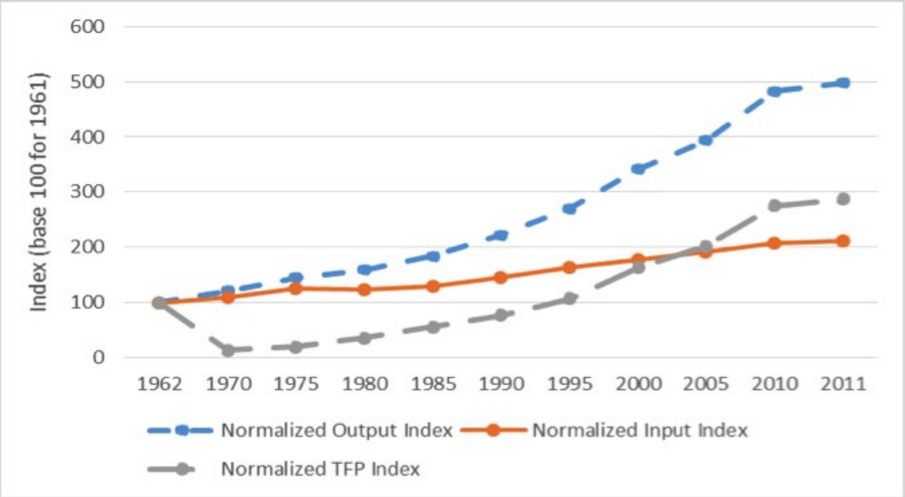
Table 8.1. Normalized (Base 100 for 1966) Values of Output, Input and TFP Indexes for Tunisian Agricultural Sector Calculated Based on the Törnqvist-Theil Method

	Normalized Output Index	Normalized Input Index	Normalized TFP Index
1966	100	100	100
1970	107.70	115.31	93.41
1975	165.57	124.31	133.19
1980	196.64	128.06	153.56
1985	265.10	138.11	191.95
1990	285.15	148.02	192.65
1995	238.66	149.09	160.08
2000	324.07	157.18	206.18
2005	404.77	177.73	227.74
2010	403.90	184.40	219.04
2011	444.42	176.24	252.16

Source: authors' elaboration (2014).

Estimation of equations (1), (2), and (3) for Egypt are presented in Figure 8.3 and Table 8.2.

Figure 8.3. Törnqvist Output, Inputs, and Total Factor Productivity Indexes, for the Egyptian Agricultural Sector (1962-2011)



Source: authors' elaboration (2014).

Furthermore, our results for the Egyptian case show that trends of agricultural, crop and livestock output values have increased faster since 1999-2000. The trends of labour, fertilizers, capital stock and seeds values have strongly increased since 1990. The crop revenue share in agricultural revenue fluctuated during 1961-2011. It decreased from 69.4% in 1961 to 61.6% in 1982, to 55.6% in 1984 and then increased to 71.5% in 1992. The share of livestock revenue in total agricultural revenue also fluctuated during the same period. It increased from 30.7% in 1961 to 38.4% in 1982, to 44.4% in 1984 and then decreased to 28.6% in 1992. These fluctuations justify the variability in the annual growth rates of the selected agricultural inputs and outputs.

The annual growth rates of the studied input and output variables range between 0.7% (e.g., natural resource quantity) and 18.2% (e.g., fertilizer values). The increase of agricultural output resulted from an increased use of traditional inputs. These were mainly cultivated areas and growth in TFP. On average, modern inputs (fertilizers and machinery) contributed little to the agricultural output growth and the difference between growth in output and the sum of total contributions by factor inputs and

TFP is about equal to growth in efficiency, which on average made the lowest contribution to growth in output.

Table 8.2. Normalized (Base 100 for 1962) Values of Output, Input and TFP Indexes for the Egyptian Agricultural Sector Calculated Based on the Törnqvist-Theil Method

	Normalized Output Index	Normalized Input Index	Normalized TFP Index
1962	100	100	100
1970	120.31	108.11	13.55
1975	144.37	125.07	19.29
1980	158.51	123.57	34.94
1985	184.17	129.21	54.95
1990	222.33	145.56	76.77
1995	270.29	163.66	106.63
2000	341.09	177.92	163.17
2005	393.48	191.52	201.96
2010	482.80	208.05	274.74
2011	498.16	211.21	286.95

Source: authors' elaboration (2014).

8.3.2 Factors Affecting Total Factor Productivity Growth

Recent developments in growth theory have stressed the importance of good institutions (North 1990, Hall and Jones 1999, Acemoglu et al. 2001) and sound policies in creating an environment that fosters economic development through accumulation of production factors and efficient use of resources. Several factors have been identified in the social science literature as the most important sources of productivity change in the agricultural sector: research and development, extension, education, infrastructure, government programs and policies, technology transfer and foreign R&D spillovers, health, structural change and resource reallocation, and terms of trade, among others. In the literature, there are several empirical studies exploring the impact of policies and institutions or these exogenous variables on the TFP growth of a number of less developed countries, including, among others, Telleria and Aw-Hassan (2011) and Dhehibi et al. (2014).

Productivity measures do not provide any information about the separate role of each of these factors. However, an understanding of the potential sources of productivity growth is important for formulating appropriate policy decisions to increase productivity and social welfare. The main explanatory variables used as determinants of agricultural TFP growth are the following:

- ***Research and Development****:* The results of agricultural research include higher yielding crop varieties, better livestock breeding practices, more effective fertilizers and pesticides, and better farm management practices. Agricultural research is required not only to increase agricultural productivity, but to keep productivity from falling. For example, yield gains for a particular plant variety tend to be lost over time because pests and diseases evolve that make the variety susceptible to attack. Thus, a large share of agricultural research expenditure is devoted to maintenance research. Farmers benefit from agricultural research in the short run because of lower costs and higher profits. However, the long-run beneficiaries of agricultural research are consumers who pay lower food prices. Agricultural research also helps maintain the competitiveness of a given country in world markets. Agricultural research can also reduce inequality in incomes and living standards because lower food prices benefit low-income people more than high-income people (low-income people spend a larger share of their income on food than do high-income people). Moreover, the major portion of public agricultural research is paid for by taxes from middle-income and high-income people. Private agricultural research is mainly performed by manufacturers of farm machinery and agrochemicals, and by food processors. Public agricultural research is performed in national agricultural experiment stations and other universities. Both public and private research has positive effects on agricultural productivity, with public research having a greater impact than private research (King et al. 2012).
- ***Extension****:* Agricultural research expenditures affect productivity after a time lag. First, a particular research project may take several years to complete. Second, it takes time for farmers to learn about and adopt the innovation. The sooner the benefits from research are received by farmers and consumers, the higher the rate of return will be for that research expenditure. The agricultural extension system aims to reduce the time lag between development of new technologies and their adoption. Extension agents disseminate information on crops, livestock and management practices to farmers and demonstrate new techniques. They also directly consult with farmers on specific production and management problems.

Unlike research, it is reasonable to assume that extension has an immediate effect on productivity.

- ***Education/Human Capital****:* Education provides individuals with general skills to solve problems. Education is thus an investment in "human capital" analogous to a farmer's investment in physical capital. Education hastens the rate of development of new technologies by training scientists. Education also speeds the rate of adoption of new technologies among farmers. Better educated farmers are more able to assess the merits of innovative technologies and adopt them quicker than non-educated farmers, as well as to successfully adapt a new technology to their particular situation.
- ***Infrastructure****:* Investment in public capital, and particularly in physical infrastructure, accounts for the largest budget share in many countries. The role of infrastructure is to expand productive capacity by increasing resources and enhancing the productivity of private invested capital (Munnell 1992). A few studies have found a significant positive relationship between infrastructure and agricultural productivity (Gopinath and Roe 1997, Yee et al. 2002). The most obvious example of how public investment in infrastructure might affect agricultural productivity is through investment in public transportation and in irrigation infrastructure. As an example, an improved highway system can allow for better market integration of farmers and can reduce costs of acquiring production inputs and of transporting outputs to market.
- ***Government Programmes and Policies****:* The role of government (at macro and micro level) in the agricultural sector is pervasive. Government programmes affect productivity by enhancing both resource allocation and output distribution through control of prices. Government farm programmes are the most common example of government involvement in agriculture. But other examples are numerous: Tax policy may be used to encourage private firms to invest in the development of innovations as well as to encourage farmers to adopt the innovations. Enhanced intellectual property rights protection may increase the incentives for private firms to engage in private agricultural research. Regulatory policies affect the rate at which new fertilizers and farm chemicals reach the marketplace. Although relatively little research has investigated the impact of government farm programmes on agricultural productivity, some of the few studies did find a significant positive relationship

(Huffman and Evenson 1993). For example, direct government payments (in terms of subsidies to acquire machinery) may encourage substitution of improved capital inputs for labour and increase the rate of new technology adoption (Makki et al. 1999).

- ***Technology Transfer: Foreign Research and Development (R&D) Spillovers****:* Isaksson (2007) indicated that knowledge is created by a small number of leader countries in technological terms. Because most countries do not produce state-of the-art technology themselves, it must be acquired from elsewhere. There are several ways in which knowledge can cross national borders. For instance, technology is often embodied in goods (e.g., irrigation materials, mechanization, etc.). Thus, imports of relatively high knowledge content can be exploited. Trade, in general, increases international contacts and can be a source of learning. Foreign R&D spillovers in the form of a research (new technologies and funding) in a foreign country can also entail technology transfers. Trade and foreign R&D spillovers, as carriers of knowledge, should probably be seen as having indirect effects on TFP, as the better they work, the stronger their impact, although with no intrinsic direct effect on their own.
- ***Structural Change and Resource Reallocation****:* Chanda and Dalgaard (2003) attempt to show that aggregate TFP is greatly influenced by the structure of the economy and here institutions are important for how the structure develops. Their main contention is that the correlation between institutions and TFP arises because the former determines the agricultural/non-agricultural composition of the economy. In economies where institutions are weak less funds are available for investment and, hence, capital accumulation. This in turn affects the output composition, since capital-intensive non-agricultural activities could offer higher wages and thereby attract labour from agriculture. It is here that human capital enters the scene. As long as human capital increases, the marginal product of labour in the non-agricultural sector will be more than in the agricultural sector, and labour will be diverted from the latter sector. Furthermore, as long as the relative productivity in agriculture is lower than that of the non-agricultural sectors, aggregate output per worker will increase.
- ***Terms of Trade****:* In the specialized literature, a number of studies have claimed that favourable agricultural terms of trade are a strategic necessity for enhancing technology adoption as well as mo-

bilization of higher investment levels in transforming agriculture (Dantwala 1976, De Janvry and Subbarao 1986). An alternate body of opinion claims that non-price factors (mainly technology, infrastructure, research and extension) are more significant for sustainable agricultural growth in world economies where prices are used as a policy instrument for obtaining a desirable allocation of resources. Changes in inter-sectoral terms of trade cause redistribution of income not only in sectors but also among income classes. Such redistributive flows of income affect the farmer's capacity for savings and incentives to invest, produce and sell. In the literature, agriculture exports and irrigation were found to have the greatest effects on technical inefficiency reduction (Ben Jemaa and Dhif 2005). Agricultural exports expose the producers in a country to an international competitiveness which stimulates efficient production technologies. Besides, agricultural imports are a sign of a low performing agricultural sector (especially when resources are not constrained). An increase in the terms of trade reduces inefficiency and consequently increases TFP. This implies that any increase of the export unit value (or similarly, any decrease of the import unit value) enhances TFP growth.

It is possible that the impacts of these factors on technical change are all positive, but to different degrees. In other words, some key determinants such as trade liberalization and domestic inputs (infrastructure, research and development, extension and technology transfer) may have a more significant impact on technical change or, conversely, on further TFP growth (TFPG). It has been a widespread belief that Tunisian and Egyptian agricultural TFPG stems from two major sources: one is the trade with foreign countries, and the other is domestic inputs aiming at research, development and extension (R, D&E) and efficiency improvement, simplified as trade liberalization and domestic inputs (Bahloul 1999, Galanopoulos et al. 2006, Dhehibi et al. 2014). In our case, trade openness is used as a proxy for trade liberalization, and domestic inputs is approximated by agricultural scientific input (scientists / year and scientists / crop land), resource reallocation, balanced territorial development and infrastructure.

To test the above hypotheses, we adopt a one-step estimation procedure where the TFPG is mainly explained by technological change (progress). We estimate the impact of a multitude of variables, including trade liberalization, domestic inputs and infrastructure, in order to get the information of contribution of each variable. In a stylized form, we used the following regression model (expected signs in parentheses):

$$LnTFPG_t = \alpha_0 + \alpha' Z_t\,(BTD_t, IIC1_t, RR_t, TO_t, INF_t) + \varepsilon_t \qquad (4)$$

Where:

LTFPG = Total Factor Productivity in the Tunisian (Egyptian) agricultural sector;

α_0 : Coefficient

Z_t : Variable vector, including:

BTD (+) = Balanced territorial development indicators: Rural GDP per capita

IIC1 (+) = Index of Innovation Invention Capital, IIC (Scientists/year)

RR (+) = Resource Reallocation: Agricultural employment share (%)

TO (+) = Trade Openness: (Import + export)/total production (%)

INF (+) = Infrastructure: Road density (expressed in km/km^2 agricultural land)

ε_t : Error term, including the rest of the factors that may influence TFP and are not considered in this equation.

The log-linear form of equation (4) allows for estimating coefficients that can be directly interpreted as elasticities. In addition, as pointed out in the pioneering work by Jud and Joseph (1974), equation (4) contains a weak residual variance relative to other functional forms for the same data set and adjusts the data better than the linear specification for both forecasted parameter signs and statistical significance. The standard Ordinary Linear Squared (OLS) method, if applied to non-stationary data series, can produce spurious regression. That is, the OLS regression can give high R^2, low Durbin-Watson (DW) statistics, and significant t-values of the estimated coefficients, suggesting a significant relationship between dependent and explanatory variables, when in fact they are completely unrelated. Conventionally, the factors explaining TFP have been studied by expressing variables in logarithmic form. This is similar to the first differencing of variables in time series analysis. Provided the original series are integrated of order 1, as is normally the case, expressing the variables in logarithmic terms ensures a stationary data series and means that the OLS method can be safely and directly used (Hendry 1995).

Tables 8.5 and 8.6 present the estimation results of equation (4) regressing the TFP on a set of economic and social variables for both Tunisia and Egypt. The results (Table 8.5) show that three (out of five) variables had significant effect on TFP in Tunisia during the period 1970-2012. These significant variables are: Trade Openness (+), Balanced Territorial Development (-) and Resource Reallocation (-), measured as agricultural employment share (% of the national employment). The indicators for estimation performance are quite satisfying. The R^2 is equal to 0.57, showing that 57% of the TFP variations in Tunisia, over the period of analysis, are explained by the regressed variables considered in our analysis. For the case of Egypt, only the infrastructure variable was significant, negatively affecting TFPG.

As expected, the estimation results indicate that trade openness has a positive impact on TFP in both countries, and consequently on technical change. However, the correspondent coefficient is significant for the case of Tunisia and neutral for the Egyptian case. The non-significance and the low magnitude of this coefficient may be due to the deterioration of the terms of trade that Tunisia and Egypt have experienced in the past 30 years.[5] This means depreciation in the terms of trade, which compels the economy to decrease its final demand as the cost of imported goods increases, a development that does not favour TFP growth. Indeed, our results are in accordance with the findings of Schiff and Valdés (1992). These authors indicate that trade policies which serve to lower agriculture's terms of trade have been a major cause of the slow growth in developing countries – precisely the opposite of the intended effect of industry-led growth strategies. Cleaver's work in 1984 also points to this predominant view that in sub-Saharan Africa trade and exchange rate policies had a negative impact on agricultural production, though his analysis suggests that these were not the most important factors impeding agricultural growth.

In addition, the estimation results show that, for technical change, all

[5] According to UNCTAD (2010) estimates, the value of the net barter terms of trade index (2000 = 100) is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000. In Tunisia, this ratio decreased from 123.60 in 1980 to 89.65 in 2007.

the variables work negatively, and of the five variables, trade openness constitutes the most important (with positive and significant impact for the Tunisian case and positive impact for Egypt). Thus, trade liberalization promotes balance and sustainable productivity growth. By contrast, agriculture infrastructure, agriculture scientific inputs (proxied by Innovation Invention Capital) and balanced territorial development work negatively, undermining a sustainable growth in the two countries.

Table 8.3. List of Input and Output Variables Used for the Tunisian Agricultural TFPG Calculation

Variables	Description	Source
Input/output variables		
Total agricultural output (in value)	This variable represents the total annul value (in current local currency) of the agricultural production in Tunisia. This variable is also disaggregated into crops and livestock outputs.	FAO database
Labour (in quantity and value)	Labour is an agricultural input. This variable represents the annual quantity (number of active persons) and value (in current local currency: LCU) of labour used in the agricultural sector. The total value is calculated based on average wages in Tunisia.	IEQ + INS Tunisia
Seeds (in quantity and value)	This variable describes the aggregated annual quantities (in tons) and values (LCU) of all crop seeds used in the agricultural sector. It does not take into consideration seedlings and saplings.	FAO database
Machinery (in quantity and value)	The machinery variable is reflected by the annual number and value (LCU) of new tractors in use. Other machinery was not considered in this input vector.	FAO database
Pesticides (in quantity and value)	The pesticide variable describes the overall annual quantities (in tons) and value (LCU) of pesticides and other treatment products used in the agricultural sector for different cropping activities.	FAO database + MARH
Feed (in quantity and value)	The feed variable describes the annual quantity (in tons) and value (LCU) of animal feed used for livestock activity in Tunisia.	FAO database + MARH
Capital stock (in quantity and value)	Capital stock is an important variable representing the annual value (LCU) of fixed inputs (land, head of livestock, tree plants, livestock infrastructure, etc.). For the quantity of this variable, we used an aggregated normalized index regrouping the annual values of the most important among these fixed capital assets.	FAO database + MARH
Natural resources (water/land) (in quantity and value)	The natural resource input vector regroups the remainder of inputs which are hard to account for. It usually includes land and water resources used for agricultural activities. The value of this input corresponds to the residual difference between the overall agricultural output value and the value of all the previous input vectors.	FAO database + MARH

Source: authors' elaboration (2014).

Table 8.4. List of Input and Output Variables Used for the Egyptian Agricultural TFPG Calculation

Variables	Description	Source
Input/output variables		
Total agricultural output (in value)	This variable represents the total annul value (in current local currency) of the agricultural production in Egypt. This variable is also disaggregated into crops and livestock outputs.	FAO database
Labour (in quantity and value)	Labour is an agricultural input. This variable represents the annual quantity (number of active persons) and value (in current local currency: LCU) of labour used in the agricultural sector. The total value is calculated based on average wages in Egypt.	MOP
Seeds (in quantity and value)	This variable describes the aggregated annual quantities (in tons) and values (LCU) of all crop seeds used in the agricultural sector. It does not take into consideration seedlings and saplings.	FAO database
Machinery (in quantity and value)	The machinery variable is reflected by the annual number and value (LCU) of new tractors in use. Other machinery was not considered in this input vector.	FAO database
Pesticides (in quantity and value)	The pesticide variable describes the overall annual quantities (in tons) and value (LCU) of pesticides and other treatment products used in the agricultural sector for different cropping activities.	FAO database
Feed (in quantity and value)	The feed variable describes the annual quantity (in tons) and value (LCU) of animal feed used for livestock activity in Egypt.	FAO database
Capital stock (in quantity and value)	Capital stock is an important variable representing the annual value (LCU) of fixed inputs (land, head of livestock, tree plants, livestock infrastructure, etc.). For the quantity of this variable, we used an aggregated normalized index regrouping the annual values of the most important among these fixed capital assets.	FAO database
Natural resources (water/land) (in quantity and value)	The natural resource input vector regroups the remainder of inputs which are hard to account for. It usually includes land and water resources used for agricultural activities. The value of this input corresponds to the residual difference between the overall agricultural output value and the value of all the previous input vectors.	FAO database + CAPMAS

Source: authors' elaboration (2014).

Table 8.5. TFPG Determinants in the Tunisian Agricultural Sector (1980-2012)

	Dependent variable $LnTFP_t$		
Parameters	Estimated coefficients	t-ratios	p-value
Constant	0.42	0.93	0.35
$LBTD_t$ (Balanced Territorial Development Indicators)	-0.63	-1.75	0.09
$LIIC1_t$ (Index of Innovation Invention Capital, IIC, # scientists/year)	-0.09	-0.50	0.61
LRR_t (Resource Reallocation: Agricultural employment share)	-2.66	-2.17	0.03
LTO_t (Trade Openness)	0.80	3.46	0.00
$LINF_t$ (Infrastructure)	-0.01	-0.11	0.90
T	33		
R^2	0.45		
F-statistic	4.45 (p<0.0043)		
Log likelihood	21.99		

Source: author's calculation based on coefficient estimates of the linear regression model (2014).

Table 8.6. TFPG Determinants in the Egyptian Agricultural Sector (1980-2012)

	Dependent variable $LnTFP_t$		
Parameters	Estimated coefficients	t-ratios	p-value
Constant	-0.12	-0.17	0.86
$LBTD_t$ (Balanced Territorial Development Indicators)	-0.07	-1.35	0.18
$LIIC1_t$ (Index of Innovation Invention Capital, IIC, # scientists/year)	0.09	0.36	0.71
LRR_t (Resource Reallocation: Agricultural employment share)	0.005	0.01	0.99
LTO_t (Trade Openness)	0.04	0.65	0.51
$LINF_t$ (Infrastructure)	-0.05	-1.60	0.12
T	33		
R^2	0.14		
F-statistic	0.81 (p<0.51)		
Log likelihood	66.65		

Source: author's calculation based on coefficient estimates of the linear regression model (2014).

Conclusions and Policy Implications

The currently analysis provides relevant results which might help us understand the structural trend of the agricultural sector in Tunisia and Egypt, as well as the most significant variables affecting this trend. The analysis was based on the calculation of the Total Factor Productivity of the agricultural sectors in both countries. Once calculated, we regressed these TFP scores on a set of potential explicative variables, including a trade variable, in order to detect the ones that most affect the productivity of agriculture in these South Mediterranean countries.

Empirical findings suggest that farming activities in Tunisia and Egypt still need much technical support, better extension, and enhancement of the comparative skills of farmers. A clear vision to promote and encourage a new generation of well-educated and specialized farmers is needed. Knowing that efficiency change had no effect on TFP means that most of the TFP growth in both countries was generated through technical change, making reference to the acquisition of new technology for farming activities. The second main result is related to the important fluctuation of the TFP in Tunisian agriculture compared to Egypt. This fluctuation in Tunisia is mainly due to the important fluctuation of the agricultural output index, which is also explained by the dominance of rainfed farming, highly dependent on climate variability. This indicates that the efforts made in Tunisia during more than 40 years to develop irrigated agriculture have not been sufficient to decrease the dependency of Tunisian agriculture on climate. It also indicates that more focus should be given to rainfed agriculture in Tunisian agricultural development strategies for the next decades. Rainfed agriculture offers important development opportunities, and around the world there are currently many calls for clear strategies to intensify this type of farming and adapt it to the challenge posed by climate change.

These findings have important policy implications for promoting further growth in the agriculture sector in both countries. Increased productivity is important for competitiveness as the countries seek to take further advantage of existing bilateral and multilateral trade partnerships (e.g., WTO, Euro-Med Free Trade Area and the Arab Maghreb Union).

Concerning TFP determinants for agricultural sectors in both Tunisia and Egypt, many important issues can be raised. First, it is clear that TFP is context-specific and its drivers are different from one country to another. In fact, the results show that the significant variables affecting TFP in Tunisia are completely different from those in Egypt. Furthermore, in Tunisia, which is a rainfed-dominated agriculture (compared to Egypt), rural development variables were found to significantly and negatively affect agricultural productivity. Put differently, when the rural GDP per capita increases, the agricultural productivity growth of the agricultural sector decreases. This also means that the productivity of the agricultural sector increases when the percentage of people employed in this sector decreases. This demonstrates that agricultural activity is still a marginalized activity which is linked to low levels of income and is a source of employment for low productive labour. This type of structural problem cannot be handled solely within the framework of an agricultural development strategy but implies a wider vision of integrated rural development where agriculture is developed in parallel/synergy with other economic sectors.

A second issue related to TFP determinants is the significance of trade openness in explaining TFP growth in Tunisia. This variable was found to be positively related to productivity gains of Tunisian agriculture, which means that enhanced agricultural trade agreements with the rest of the world are actually beneficial to the agricultural sector as a whole. However, this conclusion should not be considered in an absolute sense and more analysis should be undertaken to identify the distribution of the extra revenues generated by this trade, especially if we know that many foreign direct agricultural investments have been made in Tunisia during the last two centuries. A final issue is related to the negative significant effect of the infrastructure variable on the productivity gains of the agricultural sector in Egypt. If the coefficient of this variable was negative, this might indicate a form of low integration of farmers within large neighbouring markets. However, the positive sign of this variable could indicate the high level of fragmentation of agricultural lands due to the development of more roads and unpaved rural roads. It is again important that policy makers take a deeper look at their rural infrastructure strategy, knowing that it may affect the productivity of the agricultural sector as whole.

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