

Productivity and Economic Growth in Tunisian Agriculture: An Empirical Evidence

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Abstract- This paper analyse the patterns of productivity and economic growth in the Tunisian agriculture during the 1961–2000. Results indicated that agriculture output growth where high in both the 1961–1970 and the 1971–1980 periods but decreased during the 1991–2000 period. Average output growth exceeded 6% during the 1981–1990 period, the average output growth during 1991–2000 had fallen to 4%. Over the whole period, capital was the most important contributor to output growth and labour is considered as the least significant contributor to economic growth. Total factor productivity contribution to output growth decreased from 4.64% in 1961–1970 to 2.86% in 1971–1980. In contrast, this contribution increased in 1981-1990 to close the 4.38%. In the last period, namely 1991-2000, TFP decreased. On average, productivity growth increased by less that 3.6% per year. One major source of the low productivity might be the low level of intermediate input use.

Key-words: Production function, *Translog*, Agriculture, TFP, Tunisia.

JEL: C8, O13, O14.

1. Introduction

During the last three decades, the agricultural sector in Tunisia has undergone substantial structural changes and a new development paradigm calling for a change from state-led to private-led growth made its way in the country. Input subsidization schemes that provide little incentives for resource conservation, price support programs that distort market allocation of resources and heavy border protection making food more expensive for consumers were being increasingly recognized as inefficient ways to achieve food security and rural development objectives.

An important milestone within this time period is the Agricultural Sector Adjustment Program (ASAP) initiated by the government in 1986. The essence of this program is to: (i) remove the major sources of price distortions that adversely affect efficiency and productivity; (ii) transfer marketing functions that are under state control to the private sector; and (iii) improve the public sector management, which entails increasing privatisation.

While major revisions in past policy pricing have taken place namely, a gradual disengagement from price fixing and removal of input subsidies, it is a little surprising that empirical evidence on aggregate production structure and productivity growth in the Tunisian agricultural sector is lacking. To the authors knowledge, attempts to estimate an aggregate production model for Tunisian agriculture that simultaneously identify substitution elasticities, input demand elasticities and the rate of growth of technical change are missing despite the rich literature in this area. Indeed, the literature is awash of studies that used

aggregate production relations to examine the underlying technological structure of production. The surge in the popularity of these functions has been due in part to the advent of duality theory and to the development of flexible functional forms. The transcendental logarithmic (*translog*) function, introduced by Christensen *et al.*, (1973) has been particularly used to analyse, among others, factor input demands, substitution between production factors, returns to scale and the growth rate and bias of the occurring technological progress.

The purpose of this paper is to investigate production structure and technological change in Tunisian agriculture for the period 1961-2000. The analysis is facilitated by using a *translog* production function. The *translog* production function provides a convenient framework for analysing productive behaviour.

The paper is structured as follow. After introducing the subject and establishing the objectives, theoretical framework and model specification are presented (Section 2). The third section describes data sources and estimation procedure. Section 4 describes the empirical results and discussions. The final section summarizes major findings and conclusions.

2. Theoretical Framework and Model Specification

To study productivity in Tunisian agricultural, we adopt a production function approach. The *translog* functional form was chosen to avoid strong restrictions on the technology. The *translog* production function specification is defined as:

$$\begin{aligned} \text{Log}(Y) = & \alpha_0 + \alpha_X \log(X) + \alpha_K \log(K) + \alpha_L \log(L) + \alpha_T T + \frac{1}{2} \beta_{XX} \log(X^2) \\ & + \beta_{XK} \log(X) \cdot \log(K) + \beta_{XL} \log(X) \cdot \log(L) + \beta_{XT} \log(X) \cdot T + \frac{1}{2} \beta_{KK} \log(K^2) \\ & + \beta_{KL} \log(K) \cdot \log(L) + \beta_{KT} \log(K) \cdot T + \frac{1}{2} \beta_{LL} \log(L^2) + \beta_{LT} \log(L) \cdot T + \frac{1}{2} \beta_{TT} T^2 \end{aligned} \quad (1)$$

Where; Y: is the output; X the intermediate inputs; K the capital; L the labour, and T the time.

The function is symmetric such that $\beta_{ij} = \beta_{ji}$. We also assume that production is characterised by constant returns to scale. Under constant returns to scale, the value share for each input in the value of output is equal to the elasticity of output with respect to that input and the value shares sum up to unity.

Given the functional form defined in equation 1, we define the value shares as:

- $v_X = \alpha_X + \beta_{XX} \log X + \beta_{XK} \log K + \beta_{XL} \log L + \beta_{XT} T$
- $v_K = \alpha_K + \beta_{XK} \log X + \beta_{KK} \log K + \beta_{KL} \log L + \beta_{KT} T$
- $v_L = \alpha_L + \beta_{XL} \log X + \beta_{KL} \log K + \beta_{LL} \log L + \beta_{LT} T$

(2)

The *translog* function is characterised by constant returns to scale if and only if the parameters satisfy the conditions:

- $\alpha_X + \alpha_K + \alpha_L = 1$
- $\beta_{XX} + \beta_{XK} + \beta_{XL} = 0$
- $\beta_{XK} + \beta_{KK} + \beta_{KL} = 0$
- $\beta_{XL} + \beta_{KL} + \beta_{LL} = 0$
- $\beta_{XT} + \beta_{KT} + \beta_{LT} = 0$

(3)

3. Data Sources and Estimation Procedure

3.1. Data Sources

To implement the above-specified model, annual data from 1961 to 2000 of the Tunisian agriculture sector are used. In particular, data on output, intermediate input, capital and labour. These data are constructed from several sources. The agriculture output is taken from the Food and Agricultural Organization's online database. The current and real values (expressed in 1990 prices) of labour and intermediate input were collected from the *Institut National de la Statistique* (INS) publications. Finally, the farm capital stock variable (machinery, installations and buildings) is taken from the *Institut d'Economie Quantitative* (IEQ) publications.

3.2. Estimation Procedure

The *translog* production model, as outlined in the section above, consists of the output equation (equation 1) and the three share-equations (equation 2). This model is set up to be solved as a simultaneous equation system. For this reason, seemingly unrelated equations (1) and (2) is solved using Zellner's iterative seemingly unrelated regression (ITSUR) procedure

Since the sum of the value shares always equals one, only $n-1$ of the value shares are linearly independent. This implies that the covariance matrix disturbance is singular and non-

diagonal (Berndt, 1991). To solve the singularity problem, in a first step, the labour equation (v_L) is arbitrarily dropped from the estimation. The parameter estimates and their variances from the dropped equation can be derived by indirect estimation. In the second step and taking into account that our analysis is based on time series, we tested the auto-correlation. The resulting Durbin–Watson statistics from preliminary estimations suggested that auto-correlation is not a problem.

As well as in the third step, we tested the separability in the specification outlined above. In this case, separability addresses the question if the marginal rate of substitution between input i and j are independent of the quantities of input k . As a first test, global separability was tested. As indicated by Berndt and Christensen (1973), if global separability was rejected, we tested separability between any two pairs of inputs. Result from table 1 shown that all types of Separability (non-linear and linear) were rejected at 5% level.

Table 1. Parameter Restriction Tests.

	<i>LR – Test Statistics</i>	<i>d.f</i>	$C^2_{(0.05)}$
Hicks Neutrality	8.80	2	5.99
Separability	17.72	3	7.81
Price – Wise Separability XK-L	8.93	2	5.99
Price – Wise Separability KL-X	15.21	2	5.99
Price – Wise Separability XL-K	12.43	2	5.99
Price – Wise Non Linear Separability XK-L	17.87	3	7.81
Price – Wise Non Linear Separability KL-X	21.65	3	7.81
Price – Wise Non Linear Separability XL-K	13.25	3	7.81

Source: Own elaboration.

An important part of the estimation is to calculate the price elasticities. These provide a measure of the effects of a percentage change in the price of input i on the demand for input j . The price elasticities are defined as $\epsilon_{ij} = S_j \sigma_{ij}$, where S_j is the estimated value-share of the j th input and σ_{ij} is the partial Allen elasticity of substitution. Allen elasticity is defined as:

$$S_{ij} = \sum_{h=1}^n F_h X_h \frac{|\overline{F}_{ij}|}{X_i X_j |F|} \quad (4)$$

Where $|F|$ is the determinant of the bordered Hessian, and $|\overline{F}_{ij}|$ is the cofactor of F_{ij} in $|F|$. The price elasticities might be very important when analysing the effects of price changes on input demand especially if the public policies were pricing policies.

To close our analysis, the last step consists in measuring the total factor productivity

(TFP) growth. This concept is measured by a *Törnqvist* index. Diewert (1976) indicated that the *Törnqvist* index has been shown an exact and superlative index and a suitable discrete time approximation to the continuous time *Divisia-index*. This index has been widely used especially when the *translog* specification is considered.

Mathematically, the *Törnqvist-index* is calculated (in log form), between any two consecutive time periods, t and $t+1$, as:

$$TFP_{t,t+1} = \log Y_{t+1} - \log Y_t - \sum_{i=1}^n \frac{1}{2} [S_{i,t+1} + S_{i,t}] [\log X_{i,t+1} - \log X_{i,t}] \quad (5)$$

Where; S_i denotes the respective input's value-shares.

To complete analysis correctly, the *Törnqvist index* requires that the shares result in perfect aggregation. This is ensured by the assumption of constant returns to scale.

4. Results and Discussion

4.1. Parameters Estimation

Results from the parameter estimation are presented in table 2. Before the analysis of these parameters showed in this table, it is important to indicate that R^2 for the output equation was 0.94 with a statistic Durbin-Watson of 1.64. For the capital share equation and intermediate share equation, these coefficients were 0.46 and 0.52 for R^2 , and 1.88 and 1.96, for Durbin-Watson statistics, respectively.

Table 2. Parameter estimates of the aggregate production function for Tunisian agriculture, 1961-2000.

<i>Parameters</i>	<i>Estimate</i>	<i>Standard Error</i>	<i>Parameters</i>	<i>Estimate</i>	<i>Standard Error</i>
α_X	0.395	0.0022	β_{XT}	-0.0046	0.0000
α_K	0.037	0.0003	β_{KK}	0.0084	0.0000
α_L	0.567	0.0025	β_{KT}	-0.0005	0.0001
α_T	0.00009	0.0034	β_{LK}	0.0781	0.0008
β_{XX}	-0.514	0.0058	β_{LL}	-0.0773	0.0007
β_{XK}	-0.087	0.0007	β_{LT}	0.0052	0.0000
β_{LX}	0.601	0.0066	β_{TT}	-0.0001	0.0001

Source: Own elaboration.

Regarding estimated coefficient, both productivity growth and the acceleration of productivity growth were neutral taking into account that α_T can be interpreted as the point

estimate of productivity growth and β_{TT} as the acceleration of productivity growth. Moreover, β_{iT} parameters indicate the biases of productivity growth; Tunisian agricultural productivity growth was intermediate-input using, capital saving and labour neutral (not significant).

4.2. Price Elasticities

One of the most important concepts in this study is the estimation of own and cross price elasticities. Table 3 presents the mean values of the own and cross price elasticities for the total period and for selected sub-periods. Results from this table indicate that mean own price elasticity for intermediate input was high, -1.39 . The value of this elasticity decreases over time to reach -1.233 in 1991-2000. While, in contrast labour and capital own price elasticities were relatively low and they are maintained along the period of study.

Table 3. Mean values of prices elasticities of the aggregate production function for Tunisian agriculture, 1961-2000.

<i>Parameters</i>	<i>Mean</i>	<i>1961-1970</i>	<i>1971-1980</i>	<i>1981-1990</i>	<i>1991-2000</i>
ϵ_{XX}	-1.39	-1.59	-1.46	-1.31	-1.23
ϵ_{KK}	-0.81	-0.08	-0.81	-0.81	-0.81
ϵ_{LL}	-0.68	-0.69	-0.68	-0.68	-0.68
ϵ_{XK}	-0.08	-1.10	-0.08	-0.06	-0.05
ϵ_{KX}	-0.65	-0.90	-0.69	-0.53	-0.45
ϵ_{XL}	1.57	1.73	1.63	1.52	1.46
ϵ_{LX}	1.81	1.75	1.78	1.84	1.86
ϵ_{KL}	1.63	1.81	1.65	1.55	1.52
ϵ_{LK}	0.23	0.22	0.23	0.23	0.23

Source: Own elaboration.

In what follows, cross price-elasticities suggest that a percentage change in the price of intermediate input would have a large positive effect on demand for labour while only a modest negative effect on demand for capital. The low own-price elasticities for both labour and capital suggest low substitution possibilities for both these inputs. Demand responses from a change in capital prices were particularly highly in labour, close to 1.6. It can be observed also that high elasticity for intermediate input might be surprising in a sense since one would normally expect that intermediates such as fertilisers, seeds, etc ...are essential in agriculture and not easily substituted. These inputs need to be commercialised at the right time because the problem of seasonality in agriculture where planning is difficult.

4.3. Total Factor Productivity and Output Growth

Average annual growth rates of output and the weighted growth rates of intermediate,

capital, and labour inputs and TFP growth are showed in table 4.

Table 4. Average annual growth rates of output and weighted growth rates of inputs and productivity growth for Tunisian agriculture (%).

<i>Period</i>	<i>Output Growth</i>	<i>Intermediate Inputs</i>	<i>Capital Inputs</i>	<i>Labour Inputs</i>	<i>Productivity Growth</i>
1961-1970	5.30	0.55	6.50	0.05	4.64
1971-1980	4.67	3.08	3.10	0.06	2.86
1981-1990	6.04	2.55	2.56	0.08	4.38
1991-2000	4.03	1.88	0.72	0.42	2.63
Mean	5.00	2.00	3.14	0.158	3.60

Source: Own elaboration.

Results from this table indicate that the mean growth rates of output decreased in the 1971-1980 and in the 1991-2000 periods. Capital was the clearly dominant source of output growth in Tunisian agriculture, while labour growth was the least significant contributor to output growth. The average capital growth rates were high in both the 1961–1970 and the 1971–1980 periods but decreased substantially during 1991–2000. Labour growth fell but increased in 1991–2000 period. In the case of intermediate inputs, it can be outlined that, except the 1961-1970 period, their mean growth rates have subsequently decreased over the sub-periods. Import restrictions and lack of foreign exchange might be the major reason for the falling growth rates of intermediate inputs. In the 1991–2000 periods, the mean growth rates were very low essentially a consequence of the generally rapid increases in intermediate prices in international market in this period.

5. Conclusions and Policies Implications

The objective of this paper is to analyse the patterns of productivity and economic growth in the Tunisian agriculture during the 1961–2000. It can be observed that agriculture output growth was high in both the 1961–1970 and the 1971–1980 periods but decreased during the 1991–2000 period.

Average output growth exceeded 6% during the 1981–1990 period, the average output growth during 1991–2000 had fallen to 4%. This was well below the population growth, approximately 3%, and might indicate a matter of concern given the expressed goal of self-sufficiency in food and food security.

Over the whole period, capital was the most important contributor to output growth. In particular, capital growth was high in both the 1961–1970 and 1971–1980 periods but

decreased substantially in the 1991–2000 period. Mean growth rates of intermediate inputs subsequently decreased between 1997 and 2000. Finally, labour is considered as the least significant contributor to economic growth in the period of analysis.

Total factor productivity growth has two principal periods of evolution and two decreasing periods. Its contribution to output growth decreased from 4.64% in 1961–1970 to 2.86% in 1971–1980. In contrast, this contribution increased in 1981-1990 to close the 4.38%. In the last period, namely 1991-2000, TFP decreased. On average, productivity growth increased by less than 3.6% per year. One major source of the low productivity might be the low level of intermediate input use. In addition, several other factors can contribute to the low level of productivity. Some of them are, perhaps, poor quality of services, inability to use of production methods, physical and human capital, and the limited access to agricultural credits.

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