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Original Paper

An Attempt of Determining Some Characteristics of the Moroccan Productive System

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Abstract
The purpose of this paper is to determine some characteristics of the production system of the Moroccan economy for a single product (GDP) with annual data from 1999 to 2019. Then, we try to estimate the TFP from a translog production function to compare it with that corresponding to a Cobb-Douglas production function, if possible. The results obtained show the difficulties encountered in these estimations, particularly the multicollinearity between the explanatory variables.
keywords
Cobb-Douglas production function, translog production function, returns to scale, total factor productivity.

1. Introduction

Production theory is always at the center of economic analysis. Moreover, a production function is not only a mathematical relation, but a technical combination of inputs to obtain a product (good or service). Therefore, the knowledge of different technical parameters of this function is essential to understand and analyze the production system in a given economy.

However, in addition to the importance of the inputs that are integrated into that production function, total factor productivity (TFP) acquires a specific status. In this regard, when studying TFP, certain questions arise, such as: do all production functions succeed to explain economic growth on the basis of elements other than inputs (capital and labor)? In other words, can all production functions be used to determine and calculate TFP?

To answer these questions, it is very interesting, on one hand, to make an attempt to contribute to the richness of the economic literature on the production function and, on the other hand, to launch new areas of investigation in this field. To this end, this paper will be presented as follows: after a first section on a literature review on TFP, a second section is devoted to some macroeconomic characteristics of the Moroccan economy. Then, a third section will deal with the estimation of the parameters of a Cobb-Douglas production function and to estimate the corresponding TFP with Moroccan data. In the fourth section, an attempt is made to determine and calculate the TFP from a translog production function. Finally, a last section to conclude.

For statistical data used in this paper, we have worked with data from the National Accounts elaborated by High-Commission for Planning (www.hcp.ma), for the period 1999-2019. The year 2020 has been discarded since the Covid-19 pandemic has affected almost all economic variables.

Employment data are obtained from the National Employment Survey, an annual survey that covers the entire national territory of Morocco since 1999. The capital data series was constructed using the perpetual inventory method linking the capital stock to investment (Nehru & Dhareshwar, 1993).

Data were processed using Eviews (version 10) while the Ridge regression was done using Stata (version 16).

2. Literature Review on TFP

The economic literature is abundant with empirical research on TFP without any theory being explicitly formulated. These works are often based on the ideas developed by Solow and Swan using the growth accounting approach derived from a Cobb-Douglas production function.

Indeed, given the ease of its mathematical manipulation, Cobb-Douglas production function is used by almost all economists to support their views on the technical characteristics of the production process. But working with a production function other than Cobb-Douglas function is undoubtedly very instructive, although this undertaking is not without difficulties due essentially to the use of a production function with an unusual analytical form, as it is the case with the translog (transcendental logarithmic) production function presented in this work, and where the explanatory variables of this production function present a situation of multicollinearity in econometric treatment.

Nevertheless, the latter has been used by some researchers to estimate TFP. This is the case of (Kohli, 2015) that studied the case of the United States for the period 1970-2001. Another estimate, which was made on a panel of 41 countries, gave "unsatisfactory results not because of the production function, but because of the lack of certain statistical data" (Nehru & Dhareshwar, 1994). Also, the TFP growth rate obtained for a country is not a constant term as it is the case for a Cobb-Douglas production function, but it is an expression containing capital (K) and labor (L) components (Nehru & Dhareshwar, 1994, p. 5).

Also, in this literature review, we will present some formulas that have been given to the translog production function to compare them with that which has been used in this work.

This is mainly the case used by (Kohli, 2015) which is as follows :

$$Ln(y_t) = \alpha_0 + \beta_K * Ln(x_{K,t}) + (1-\beta_K) * Ln(x_{L,t}) + \frac{1}{2} * \phi_{KK} * \left(Ln(x_{K,t}) - Ln(x_{L,t})\right)^2 + \beta_T * t + \phi_{KT} * \left(Ln(x_{K,t}) - Ln(x_{L,t})\right) * t + \frac{1}{2} * \phi_{TT} * t^2 \quad (1)$$

This equation is static and, in addition to the quadratic elements, it includes a "trend" variable.

Thus, at a time when the most widely used specification for determining TFP is the Cobb-Douglas production function, the specification based on a translog production function is rare.

3. Some Macroeconomic Characteristics of the Moroccan Economy

The Moroccan economy is characterized by a domination of the agricultural sector which depends on rainfall. As a result, growth is dependent on climatic conditions and often presents a sawtooth pattern.

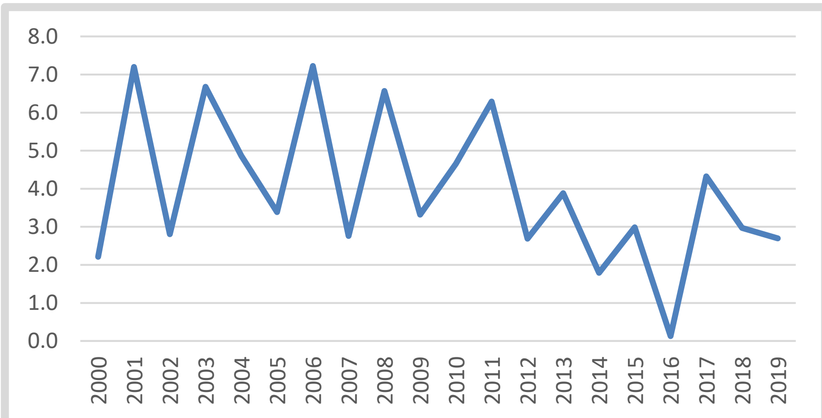

Figure 1. Economic Growth Rate (in %)

According to Figure 1, the best performance was achieved in 2001 and 2006 with almost 7.2%, while the worst performance was recorded in 2016 with 0.1%.

For its part, labor productivity is, by convention, measured as the real output per person employed. Thus, Figure 2 gives the labor productivity for the Moroccan economy between 1999 and 2019.

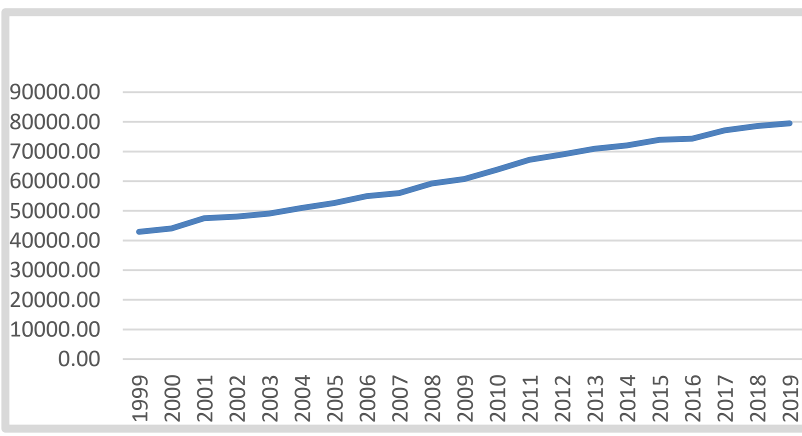

Figure 2. Average Productivity of Labor

Given that, in terms of growth rates, if P denotes labor productivity, then: $P = \frac{Y}{L}$ and labor productivity change (in percentage) is: $\frac{dP}{P} = \frac{dY}{Y} - \frac{dL}{L}$.

So, Figure 3 shows the evolution of labor productivity change (in percentage).

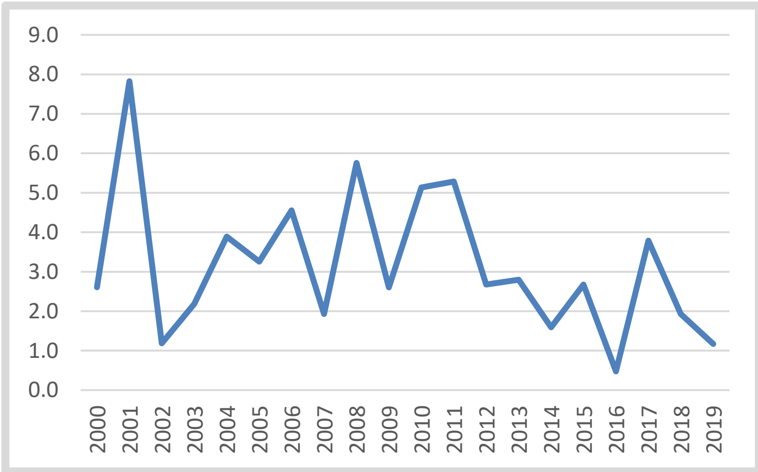

Figure 3. Change of Labor Productivity (in %)

Similarly, capital productivity refers to the ratio of real output to the stock of fixed capital used in the production process. Thus, Figure 4 shows the evolution of capital productivity for the period 1999-2019. The decrease of this curve means that capital stock increased over time.

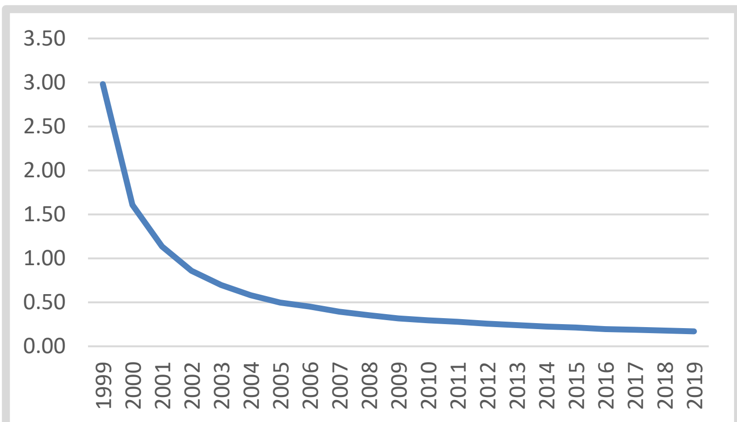

Figure 4. Average Productivity of Capital

Also, the Figure 4 shows that average productivity of capital started with 3 in 1999 and it decreased to achieve about 0,2 in 2019.

Finally, output per capita (or the intensive form of production) shows, in Figure 5, how real GDP per capita varies when capital per capita varies.

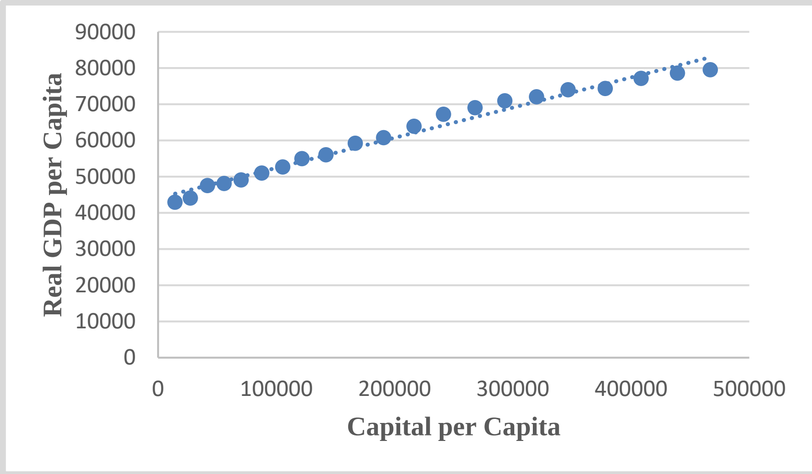

Figure 5. Real GDP Per Capita and Capital Per Capita (in Mn DH)

4. Estimation of a Cobb-Douglas Production Function Parameters

Given a production function linking the output Y to the physical inputs, capital K and labor L. This production function, having the Cobb-Douglas form, is written as follows (World Bank, 2000):

$$Y = A * (K^{\alpha} * L^{1-\alpha})^{\gamma} \quad (2)$$

with:

Y: total aggregate output (GDP in volume);

K: capital (capital stock calculated using the perpetual inventory method);

L: labor (employed labor force);

A: factor productivity;

α: production-capital elasticity which measures the importance of physical capital in production ($\alpha > 0$);

$\beta = (1 - \alpha)$: production-labor elasticity ($\beta > 0$).

γ: measures returns to scale. Thus, if $\gamma = 1$ ($\gamma > 1$) ($\gamma < 1$), then the returns to scale are constant (increasing) (decreasing).

Y, K and L are measured independently while the parameters are to be estimated. So, the estimation of this equation will allow us to find the desired parameters. Thus, a logarithmic writing of the above function will allow us to write :

$$Ln(Y) = Ln(A) + \gamma * \alpha * Ln(K) + \gamma * (1 - \alpha) * Ln(L) \quad (3)$$

The estimation of equation (3) was performed by the ordinary least squares method and yielded to the following results (where the numbers in parentheses are the t-Student):

$$Ln(Y) = -10{,}5 + 0{,}43 * Ln(K) + 1{,}1 * Ln(L) \quad (4)$$

$$(-4) \quad (20{,}8) \quad (6{,}1)$$

From this equation, we obtain the following values of α and γ:

$$\begin{cases} \alpha = 0{,}3 \\ \gamma = 1{,}5 \end{cases}$$

Thus, the share of capital in GDP is 30%, while the estimated production function is not at constant returns to scale. Similarly, an interpretation of these results shows that the national productive system is always more labor intensive, contrary to the prevailing belief that the Moroccan productive system is capital intensive.

The value γ = 1,5 gives the production function increasing returns to scale; this means that output grows more than the factors of production (capital and labor).

TFP's wording

From the production function having the Cobb-Douglas form given in (3) (with γ = 1), we obtain:

$$\frac{dA}{A} = \frac{dY}{Y} - \alpha * \frac{dK}{K} - (1-\alpha) * \frac{dL}{L} \quad (5)$$

This relationship expresses the growth rate of TFP.

From relation (5), we can say that a TFP growth rate equal to zero corresponds to a situation where the inputs are measured exactly and the production function is well specified. In this case, one can say that all output is explained only by the factors of production and there is no place for the qualitative aspects of growth such as corruption, governance, democracy, market rules, rule of law, ...etc.

Decomposition of labor productivity growth

From the relation (5), we can write:

$$\frac{dY}{Y} = \frac{dA}{A} + \alpha * \frac{dK}{K} + (1-\alpha) * \frac{dL}{L} \quad (6)$$

By rearranging the above equation, we can decompose labor productivity growth into a component called "capital deepening" and a component called "technical change":

$$\underbrace{\frac{dY}{Y} - \frac{dL}{L}}_{\text{Labor productivity growth}} = \underbrace{\alpha * \left(\frac{dK}{K} - \frac{dL}{L}\right)}_{\text{Capital deepening}} + \underbrace{\frac{dA}{A}}_{\text{Technical change}} \quad (7)$$

Estimation of the parameter α

The objective of this paragraph is to estimate the parameter α of a Cobb-Douglas production function with constant returns to scale. This production function has the following form (obtained when γ = 1 in relation (2)):

$$Y = A * K^{\alpha} * L^{1-\alpha} \quad (8)$$

In terms of intensive form of production function (or output per worker), we get:

$$\left(\frac{Y}{L}\right) = A * \left(\frac{K}{L}\right)^{\alpha} \quad (9)$$

The estimation of equation (9) by the ordinary least squares method gives (Oulad El Fakir, 2022):

$$\begin{cases} \mathrm{Ln}\left(\frac{Y}{L}\right) = 0{,}01 + 0{,}45 * \mathrm{Ln}\left(\frac{K}{L}\right) \\ R^2 = 0{,}12 \qquad \mathrm{DW} = 2{,}45 \end{cases}$$

Calculating A for each year (A_t) gives :

$$A_t = \frac{Y_t}{K_t^{0,45} * L_t^{0,55}} \quad (10)$$

This method differs from that used by Solow (Solow, 1957) which, once the growth rate of A was calculated, used the fact that: $A(t+1) = A(t) * \left[1 + \frac{\Delta A(t)}{A(t)}\right]$ to construct the time series of A(t) by arbitrarily taking A(1909) = 1.

Thus, applying relation (10), we obtain a series of A for the period from 2000 to 2019 whose mean is :

$$A = 0{,}12$$

Finally, we obtain:

$$Y = 0{,}12 * K^{0{,}45} * L^{0{,}55} \tag{11}$$

This result shows that the output-capital elasticity is 45% while that of labor is 55%.

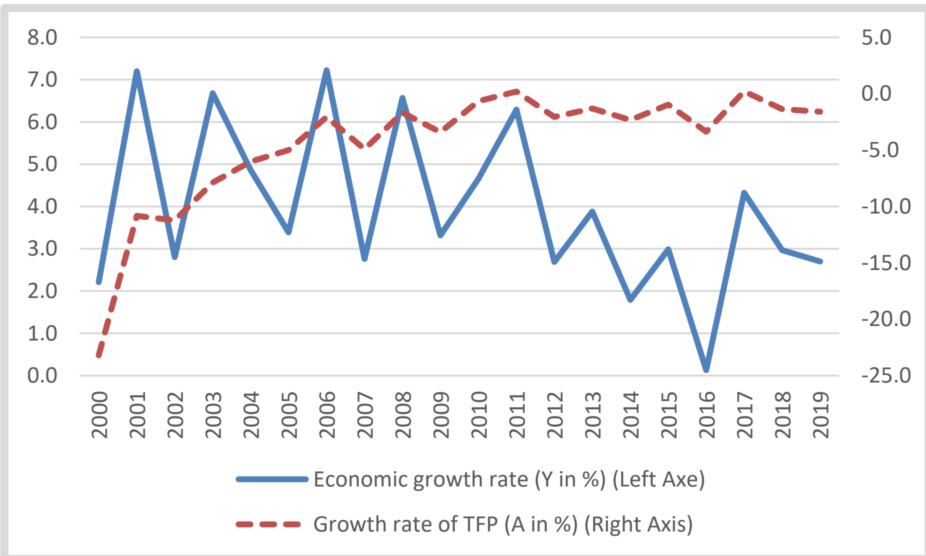

Figure 6. Growth Rate of GDP Per Worker and TFP Growth Rate (in %)

Figure 6 gives average growth rate of real GDP and average growth rate of TFP. Also, it shows that TFP growth rate had negative values before 2009 and since this date it started to have slightly positive values. Regarding the correlation between these two variables, it is very weak as the correlation coefficient is equal to 0,09. That means that these two variables are almost independent.

5. Estimating TFP from a Translog Production Function

The translog production function is a function that offers a richer and more flexible description of the technology insofar as it does not require that marginal factor productivities and/or elasticities of substitution be constant. Its estimation involves many quadratic terms. However, collinearity problems can be relatively important for some terms (Cueva & Heyer, 1997). In general, a translog production function, for m inputs X_i, is as follows (MISHRA, 2007, p. 6):

$$Ln(Y) = \alpha_0 + \sum_i \alpha_i * Ln(X_i) + \sum_i \sum_j \gamma_{ij} * Ln(X_i) * Ln(X_j) \tag{12}$$

This formulation gives rise to many quadratic terms whose estimation suffers from multicollinearity problems.

We will take the case of a translog production function of order 2. Thus, if Y is a translog production function (for the case of two inputs, capital K and labor L), its mathematical expression is as follows:

$$Ln(Y) = \alpha_0 + \alpha_1 * Ln(K) + \alpha_2 * Ln(L) + \gamma_1 * Ln(K) * Ln(L) + \gamma_2 * \left(Ln(K)\right)^2 + \gamma_3 * \left(Ln(L)\right)^2 \quad (13)$$

Let us show how a Cobb-Douglas type production function comes from a translog type production function:

For $\gamma_1 = \gamma_2 = \gamma_3 = 0$, we obtain a Cobb-Douglas type production function. Indeed, the equation given in (13) becomes:

$$Ln(Y) = \alpha_0 + \alpha_1 * Ln(K) + \alpha_2 * Ln(L)$$

Switching to exponential, we get:

$$Y = exp\{\alpha_0 + \alpha_1 * Ln(K) + \alpha_2 * Ln(L)\} = A * K^{\alpha_1} * L^{\alpha_2}$$

This is indeed the expression of a Cobb-Douglas type production function.

TFP for the case of a translog production function

To estimate the TFP, we will use the translog production function given in (13):

$$Ln(Y) = \alpha_0 + \alpha_1 * Ln(K) + \alpha_2 * Ln(L) + \gamma_1 * Ln(K) * Ln(L) + \gamma_2 * \left(Ln(K)\right)^2 + \gamma_3 * \left(Ln(L)\right)^2$$

A first attempt to estimate this equation came up against the problem of multicollinearity. This multicollinearity reflects the abundance of information expressed by the different explanatory variables present in this equation.

This shows that we cannot distinguish the individual effects of the independent variables on the dependent variable. As a result, other methods must be used to estimate this equation. So, using the "Ridge Regression" method in STATA (ridgereg) for λ=0.03 allowed the solution of equation (13) and we obtained:

$$Z = 0{,}175 * A - 0{,}135 * B + 0{,}03 * U + 0{,}02 * V + 0{,}08 * W \quad (14)$$

Note that the constant term (α_0) is statistically zero. Indeed, the presence of multicollinearity requires us to perform this regression without a constant term.

Returning to the initial variables allows us to write:

$$Ln(Y) = 0{,}175 * Ln(K) - 0{,}135 * Ln(L) + 0{,}03 * Ln(K) * Ln(L) + 0{,}02 * (Ln(K))^2 + 0{,}08 * (Ln(L))^2 \quad (15)$$

6. Comparison between the Two TFP Obtained

This part consists in comparing the TFP obtained from the two previous formulations (Cobb-Douglas and translog).

Estimation of the Cobb-Douglas type production function:

$$Y = 0{,}12 * K^{0{,}45} * L^{0{,}55} \quad (16)$$

Estimation of the translog production function:

$$Ln(Y) = 0{,}175 * Ln(K) - 0{,}135 * Ln(L) + 0{,}03 * Ln(K) * Ln(L) + 0{,}02 * (Ln(K))^2 + 0{,}08 * (Ln(L))^2 \quad (15)$$

The comparison of equations (11) and (15) does not allow us to conclude about the TFP since these two equations do not have the same arguments. But, a reading of the elasticities allows us to conclude the following:

Type of production function	Cobb-Douglas production Function	Translog production Function
Output/capital elasticity	0,45	0,18
Output/labor elasticity	0,55	-0,14

Note that with the combined effects of the two factors at the level of the translog production function, we cannot say that a negative elasticity makes sense. Similarly, one cannot say anything about the preference of one formulation or the other to represent the production function because these two formulations do not have the same arguments. Therefore, it is useless to make a comparison between them.

At the end of this article, and to conclude, we can say that if the TFP is a “measure of our ignorance”, our inability to find solutions to some of the problems posed is the expression of our true ignorance.

Indeed, if the Cobb-Douglas type production function is easy to handle mathematically and adheres to all the properties required for a production function, the case of using a translog type production function reflects a very high level of difficulty and is sometimes useless for the estimation of TFP.

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