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TOTAL FACTOR PRODUCTIVITY AND SOURCES OF ECONOMIC GROWTH IN ALGERIA (1970-2018) BY USING ARDL APPROACH

PRODUCTIVITE TOTAL DES FACTEURS ET SOURCES DE CROISSANCE ECONOMIQUE EN ALGERIE (1970-2018): UNE APPLICATION DE L4APPROACH ARDL

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ABSTRACT

The main purpose of this paper is to propose a suitable econometric model for measure the contribution of the total factor productivity (TFP) to economic growth in Algeria over the period 1970–2018, in order to determine its main sources. This paper provides an explicit application of the TFP estimation by using a parametric approach under growth accounting framework (Solow model). An ARDL model is used to estimate the TFP. The results show that the contribution of TFP in Algeria's economic growth remains disappointing and it has achieved an average growth rate of 1.01% per year during the study period. The source of overall growth has been driven mainly by factors accumulation: physical capital stock with 45.11% of contribution and labor force with 40.18% of contribution and then by TFP (technology) by only 14.71% of contribution .

Keywords : Economic growth; capital stock; labor force ; Total Factor Productivity; Algeria, ARDL approach.

JEL classification : B22 ; C51 ; O47

RESUME

L'objet principal de cet article est de proposer un modèle économétrique permettant de mesurer la contribution de la productivité totale des facteurs (PTF) à la croissance économique en Algérie sur la période (1970–2018) afin de déterminer ses principales sources. Le papier fournit une application explicite de l'estimation de la PTF en utilisant une approche paramétrique qui est un modèle ARDL, dans un cadre de comptabilité de la croissance (model de Solow).
En termes de résultats, la contribution de la PTF à la croissance économique de l'Algérie reste décevante avec un taux de croissance moyen de 1,01% par an au cours de la période d'étude. Tandis que la source de la croissance économique algérienne globale a été principalement due à l'accumulation des facteurs : stock de capital physique avec une contribution de 45,11% et main-d'œuvre avec 40,18% de contribution, puis la contribution de la PTF (technologie) qui reste très faible (seulement à 14,71%).

Mots clés : Croissance économique ; capital stock ; force de travail ; productivité totale des facteurs ; Algérie ; model ARDL.

Classification JEL: B22; C51; O47

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INTRODUCTION

Almost every developing country is suffering from two major issues; the first one focuses on how to reach economic growth rate and second how to sustain economic growth rate. Sustaining high growth rate is more difficult in developing countries. (Kashif Munir, 2017). For this, many economic analysis studies in the literature of developed and developing countries on the causes and consequences of economic growth and, at the same time, on the specific sources of economic growth have been realized. An important question arises in the debate of long-run economic growth sources: how much of economic growth is due to increases in physical and human capital, and how much is due to other factors such as technology and institutional change. (Chaudhry, 2009).

Technology is one of the major drivers of economic growth. Many scholars emphasized that technology can be measured through total factor productivity (TFP) levels. (Misra, et al, 2015). According to Solow (1956), the residual part of economic growth not explained by an increase in physical and human capital represents the total factor productivity, which is generally assimilated into technical progress even if it represents all other sources of growth not taken into account by the first two production factors. We are talking about the "Solow residual" or, according to Abramovitz (1956) who calls him "a measure of our ignorance".

Most economic analysis of TFP growth focus on the difference of technology growth between countries rather than TFP growth in the same country, while our study aims to measure TFP growth in Algeria as a whole and decompose economic growth into its components, either capital accumulation and labor force, and the residual component (TFP). There are several ways to estimate TFP for a country including the Solow growth accounting approach (basic method) which is based on constant returns to scale and perfect competition assumptions, the non-parametric approach (Malmquist Index) and the parametric or econometric approach (modelization). (Chaudhry, 2009)

The most important contribution of this paper is the application of the parametric (econometric) approach to estimate the TFP and decompose economic growth by providing an ARDL model. The results of this study help the policymakers to design appropriate policies to accelerate and sustain economic growth.

The structure of this document is as follows: Section II provides a recent literature review on relationship analysis between total factor productivity and economic growth. Section III discusses the theoretical framework, data, and model. Section V presents the empirical results of the analysis. The conclusion is presented in Section VI.

1. LITERATURE REVIEW

1.1 THEORICAL LITERATURE

Solow (1956) noted that economies never reach the stage of the steady-state of growth (which is justified by the diminishing returns of production factors) thanks to technical progress. In his second work (1957)The results he concluded that in the long-run, growth comes from technical progress that increases factors productivity. However, this one is exogenous, that is to say, that it does not explain it but considers it like a factor (such as a "manna fallen from the sky").

Charles R. Hulten (2009) presents the growth accounting framework with its assumptions (discussed in the next section) and its difficulties and criticisms about measuring inputs and output. First, capital is measured by the physical quantity and not by capital services. Second, the problem of different types of labor input (quality of work) where it should be grouped into a single quality, and then the problem of using gross output versus using the real value-added that excludes intermediate flows to measuring outputs. The author claims that growth accounting is, first and last, a diagnostic technique that relies more on good data than on high theory.

1.2 EMPIRICAL LITERATURE

Several empirical studies have been conducted on developed and developing economies to explain how economic growth can be attributed to growth in factors accumulation and total factor productivity.

In an important study, Azam Amjad Chaudhry (2009) analyzes the TFP of Agricultural and Manufacturing Sectors in Pakistan than for the economy as a whole over the period 1985-2005. The findings show that in manufacturing, productivity increased at an average of 2.4% per year with output growth being driven mainly by increases in capital. While about agricultural, productivity has grown at an average rate of 1.75% per year and the major drivers of growth in agriculture have been increases in labor and TFP. For the economy as a whole, TFP has increased at an average rate of only 1.1% a year in Pakistan, resulting in almost three-quarters of GDP growth attributed to increases in labor and the capital stock.

Alejandro Quijada (2004) in his study, focuses on the explanatory elements of growth in the long-run in Venezuela (1942-2002), including the impact of institutional change on factor accumulation, and gives particular importance to the contribution of TFP to economic growth and measured it by using both of growth accounting approach and econometric approach at the aggregated and disaggregated (oil and non-oil sector) level in Venezuela. Methodologically, the author points out that the econometric approach facilitates the analysis of the main determinants of growth and has more power than the accounting approach. In terms of results, especially the TFP, he marked its importance as an explanatory element of the economic growth in Venezuela through its effect on the oil sector (from 1993 to 2002 the fall of the TFP contributes in 105% to the contraction GDP).

Peter E. Robertson (2013) provides a quantitative assessment of the factors contributing to India's growth acceleration since 1970, based on the neoclassical growth model. An increase in the TFP growth rate from 1970 accounts for 68% of India's post-1970s growth and the rise in the investment rate accounts for 30%. Hence, an upward trend in productivity growth has been more than twice as important as the doubling of the investment rate. A similar conclusion applies for the post-2000 era, where a rise in investment from 25% to 37% of GDP, only adds about 0.7 percentage points of growth to the annual growth rate (4.5% over this period).

2. THEORICAL FRAMEWORK, DATA AND MODEL

2.1. THEORICAL FRAMEWORK

The total factor productivity was introduced for the first time by Solow (1956) and Abramovitz (1956) and was theoretically formalized in the seminal paper of Solow (1957) according to exogenous economic growth theory and measured through "Growth accounting approach". Although methodological differences remain, there is a broad consensus around the Denison (1972) - Jorgenson (1967) - Griliches (1967) – Solow (1957) conceptual framework for measuring aggregate total factor productivity growth. (Abdesselam Bouhia, 2000).
The first objective of growth accounting is to separate out the contributions of physical and human capital from the contribution of TFP to economic growth. Secondly, to understand the nature of economic growth better if it is an extensive or intensive growth[1].

Growth accounting methodology uses the Cobb Douglas production function:

$$Y=A.\ K^{\alpha}.L^{\beta}$$

Where Y is output, L is labor force employed, K is capital stock employed, α and β are, successively, capital's and labor's share in gross income, and A is a technical progress term which represents TFP.
The TFP measure is based on the calculation of the differences between the growth of real output and the growth of the factors of production used, physical and human capital. This deviation can be calculated as follows:
Taking logarithms and differentiating over time allows us to rewrite the Cobb-Douglas function as:

$$\frac{\dot{Y}_t}{Y_t} = \boldsymbol{\alpha}\frac{\dot{K}_t}{K_t} + \boldsymbol{\beta}\frac{\dot{L}_t}{L_t} + \frac{\dot{A}_t}{A_t} \ \ldots . (1)$$

This equation means that output growth is equal to weighted growth rates of capital and labor plus the growth rate of TFP (technical change).

[1] Extensive growth is the economic growth that results from the increase in the quantity of production factors used, while the Intensive growth is the economic growth due to better use of production factors (efficient combination), ie high total factor productivity.

Therefore, the growth rate of TFP or the Solow residual (R_t) is given by:

$$\boldsymbol{R_t} = \frac{\dot{Y}_t}{Y_t} - \alpha\frac{\dot{K}_t}{K_t} - \beta\frac{\dot{L}_t}{L_t} = \frac{\dot{A}_t}{A_t} \quad \ldots . (2)$$

This model requires the existence of assumptions' set; which are the following :
- Constant returns to scale ($\alpha+\beta=1$).
- Pure and perfect competition market.
- Exogenous technical change and has Hicks' neutral form.[2]
- Inputs are paid the value of their marginal product.[3]

Hence, growth accounting methodology is just a theoretical approach. In fact, at empirical applications, several are the criticisms of this methodology, it is based on unrealistic assumptions. Because of the limitations of its assumptions, The parametric approach has several features, which make it an attractive approach.

The great advantage of econometric estimation is the flexibility of the hypotheses. First of all, returns to scale can be increasing, decreasing or constant. Second, it allows choosing a more flexible production function. Third, it is not obligatory to have a perfect competition market. However, the parametric approach also suffers from problems related to measurement errors of some aggregates, the non-stationarity also pose significant constraints on estimation procedures.

Despite in the last two decades, the productivity growth measurement literature employed standard calculations of TFP growth (Kumar, 2006), the parametric approach is another popular method in the productivity analysis field. To make this contribution more complete, the parametric approach will be included in future research to calculate the TFP. (Misra et al., 2015).

2.2 DATA AND VARIABLES

This paper uses annual time-series data for Algeria over the period 1970 to 2018. The main types of data are collected from World Bank Development Indicators (World Bank), and from the National Office of Statistics (NOS) in Algeria.

- The dependent variable, **Gross Domestic Product** (**GDP**), is represented by the real GDP (GDP in constant US $ of 2010).
- The first explanatory variable, **labor force**, should be measured in terms of total hours worked, but this type of statistical information is not available at the aggregate level, what makes it necessary to use a proxy such as **Total Active Population (TAP)**.
- The second explanatory variable, **Capital Stock[4] (CS)**, is estimated by the perpetual inventory method (suggested by Haberger and others, 1978) using Gross Fixed Capital Formation.

The capital stock is given by the following formula:

$$K_t = I_t + (1-\delta)\, K_{t-1}$$

Where K_t is the real capital Stock, I_t is the real investment taken from the World Bank database (gross fixed capital formation in constant US $ of 2010), δ is depreciation rate of capital and assumed to be constant (5% is the general depreciate rate according to some studies done by the organization for economic co-operation and development OECD on several Third World countries whose economies are similar to ours).

While the initial capital stock is calculated as follows:

$$K_0 = I_0 \,/\, (g+\delta)$$

[2] Technical change has a Hicks' neutral form means that it increases the efficiency of both labor and capital factors: Q=A.F(L,K).
[3] α and β represent capital's and labor's share in total income only if we assume that the factors are remunerated at their marginal productivity.
[4] The capital stock is defined as the sum of all fixed assets values in a given territory and at a given time (usually one year).

g is the average growth rate of I_t.

2.3 MODEL SELECTION

This study focuses on the parametric (econometric) approach (using the same growth accounting framework) and investigates the relationship between factors accumulation (capital and labor) and GDP using the following Cobb Douglas production function:

$$GDP_t = A_t . K_t^{\alpha} . L_t^{\beta} \quad ..... (3)$$

Where GDP_t is the real gross domestic product, A_t is total factor productivity, K_t is real capital stock, L_t is employed labor force, α and β is the elasticity of real capital stock and effective labor respectively.
Taking the log of equation (3):

$$\text{Log } GDP_t = \text{Log } (A_t) + \alpha \text{ Log } (K_t) + \beta \text{ Log } (L_t) \quad .... (4)$$

Hence, the basic econometric model from equation (4) can be written as:

$$gdp_t = C_t + \alpha \, CS_t + \beta \, TAP_t + \mu_t \quad .... (5)$$

Where gdp_t= Log GDP_t , C_t is a constant, CS_t= Log (K_t), TAP_t= Log (L_t), and error term, μ_t=Log (A_t) which represents the total factor productivity.

Time series data needs special treatment because of standard estimation techniques on non- stationary series yield spurious regression and misleading results. (Kashif Munir, 2017). Dickey and Fuller (1981) and Phillips and Perron (1988) tests are used to testing the stationary of the series at different levels of integration.
There are various techniques that are used to check the cointegration (long-run relationship) between variables (Engle and Granger, 1987; Johansen and Juselius, 1990; Johansen, 1995) but the majority these techniques require that the variables are integrated of the same order. Moreover, if the data sample is small then these cointegration techniques are not reliable. (Kashif Munir, 2017). Therefore, to avoid these problems there is another technique introduced first by (Pesaran & Shin, 1999) and further extended by (Pesaran & al, 2001) which is known as "Autoregressive Distributive Lag (ARDL)".

The ARDL model is better than other techniques because it gives more accurate result when regressors are purely integrated of order zero or one (I(0) or I(1)) or a mixture of I (0) and I (1), provided that none of the variables is integrated of order I (2) or more. In addition it has more power and recommended when sample size is small (Pesaran & al, 2001); (Ghatak & Siddiki, 2001); (Acaravci & Ozturk, 2012) and its popularity also stems from the fact that cointegration of nonstationary variables is equivalent to an error correction (EC) process, and the ARDL model has a reparameterization in EC form (Engle and Granger, 1987; Hassler and Wolters, 2006). The existence of a cointegrating relationship can be tested based on the bound testing procedure is available to draw a conclusion inference. (Pesaran, Shin, and Smith, 2001).

Our specification of the ARDL model is formulated as follows:

$$\Delta GDP_t = C_t + \sum_{i=1}^{p} \gamma_i \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_i \Delta CS_{t-i} + \sum_{i=1}^{p} \beta_i \Delta TAP_{t-i} + \varphi_1 GDP_{t-1} + \varphi_2 CS_{t-1} + \varphi_3 TAP_{t-1} + \varepsilon_t$$

Where, α, β, and γ are representing the short-run dynamics and $\varphi1$, $\varphi2$, and $\varphi3$ are long-run coefficients which show the marginal change in the dependent variable (GDP) due to change in the explanatory variables (K and L).

3. EMPIRICAL RESULTS

3.1 ORDER OF INTEGRATION AND STATIONARY OF SERIALS

There are many tests to verify that data is not violating the assumptions of the ARDL bound testing approach, and this study uses the Augmented Dickey-Fuller (ADF) test. The results of the unit root tests show that, at a 5% significance level, all variables are integrated of order I(1).

Table1: ADF unit test root test - order of integration

Variables	*Augmented Dickey-Fuller Unit Root Test*				*Order of Integration*
	At Level		*At 1st Difference*		
	t-statistic	*Critical Value (5%)*	*t-statistic*	*Critical Value (5%)*	
GDP	*5.2972*	*-1.9479*	*-5.6458*	*-1.9479**	*I (1)*
CS	*3.8631*	*-1.9481*	*-12.8332*	*-1.9481**	*I (1)*
TAP	*5.1346*	*-1.9479*	*-3.6318*	*-1.9479**	*I (1)*

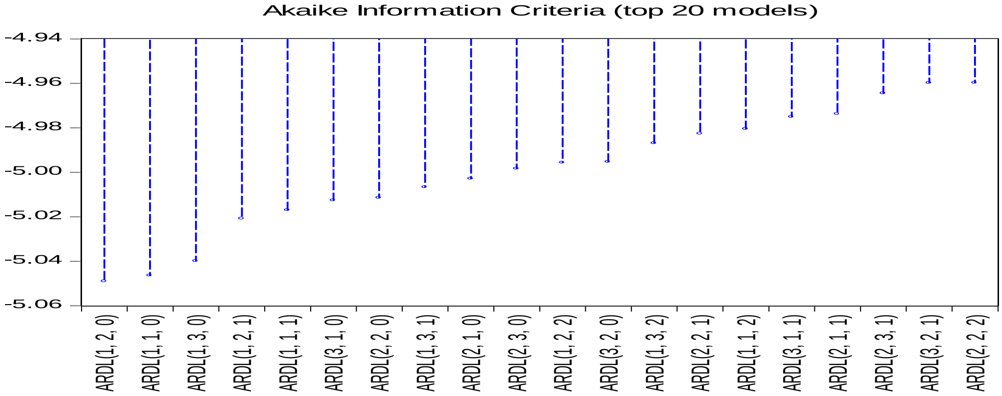
*Note: * shows significance at 5% level.*

Source: Author's computation from E-View 9.0

3.2 ARDL MODEL ESTIMATION

To visualize the optimal ARDL model, we extract the optimal lag graph according to the Akaike information criteria (AIC). The model that offers the smallest AIC value will be the best. In this case, ARDL (1,2,0) is the best.

Figure1: Optimal lags



Source: Author's computation from EVIEWS 9.0

Table 2 reports the results of the unrestricted ARDL model. The adjusted R-squared is 0.99 which implies that 99% of the GDP change is explained by independent variables (CS and TAP). In addition, the probability of F-statistic (less than 5%) definitely rejects the null hypothesis that all regressors have zero coefficients for all cases.

Table 2: Unrestricted ARDL Model

Dependent Variable: gdp *Selected Model: ARDL(1, 2, 0)*	
Variable	*Coefficient*
GDP (-1)	*0.7861 (0.0000)**
CS	*0.2664 (0.0000)**
CS(-1)	*-0.2895 (0.0000)**
CS(-2)	*0.1208 (0.0000)**
TAP	*0.0776 (0.0140)**
C	*0.7958 (0.0010)**
F-statistic	*3283.6 (0.000000)*

*adjusted **R-squared***	*0.9972*

*Note: * shows significance at 5% level.*

Source: Author's computation from EVIEWS 9.0

3.3 BOUND TEST

The next step is to check for the cointegration by applying bound test using (1,2,0) model specification (lag selection according to AIC). Narayan (2004) tabulated two sets of critical values, the upper bound critical values, I(1), and the lower bound critical values, I(0). When the computed F-statistic is greater than the upper bound critical value, we can reject the null hypothesis H0 meaning that the variables are co-integrated. But If the F-statistic is less than the lower bound critical value, we cannot reject the null hypothesis H0, meaning that there is no cointegration relationship among variables. When the computed computed F-statistics falls between the lower and upper bound, then the results are inconclusive.

The results of the bound test are reported in table 3. F-statistics is 6.29 and it falls above the upper bound at 5% significance level. So, the null hypothesis of no co-integration is rejected. Therefore, there is a long-run relationship between the GDP and factors accumulation.

Table 3: ARDL Bounds Test

Test Statistic	***Value***	***K***
F-statistic	*6.2924*	*2*
Critical Value Bounds		
Significance	***I_0 Bounds***	***I_1 Bounds***
10%	*3.17*	*4.14*
5%	*3.79*	*4.85*
1%	*5.15*	*6.36*

Source: Author's computation from E-View 9.0

3.4 DIAGNOSTIC TESTS

Before estimating the long-run and short-run parameters, it is necessary to check for diagnostic tests to avoid the misleading conclusion. These tests are performed to evaluate the robustness of our ARDL model: the Jarque-Bera test for the normality of residuals, heteroscedasticity test, and LM test for no suffering from serial correlation. The results of diagnostic tests are reported in table 4.

Table 4: Diagnostic Tests

Test	*F-statistics (p-values)*	*Results*
Residual Normality: ***Jarque Berra Test***	*1.760057* *(0.4147)*	*Normal distribution*
Heteroscedasticity: ***Breusch-Pagan-Godfrey Test***	*1.008241* *(0.4255)*	*No Heteroscedasticity*
Serial Correlation: ***Breusch-Godfrey LM Test***	*1.134578* *(0.3322)*	*No serial correlation*

Source: Author's computation from E-View 9.0

3.5 LONG-RUN AND SHORT-RUN DYNAMICS

In macroeconomics study, we give more importance to the long-run effects than those of the short-run. For this reason, we give a huge value in our study to the long-run relationship interpretation.
The bound test finds co-integration between factors accumulation and GDP. Therefore, long-run parameters are estimated and presented in Table 5.

The coefficients of real capital stock (CS) and the total active population (TAP) are positives and statistically significant. This allows us to say that an increase of the capital stock by 1% can increase economic growth by 0.46%, while the total active population increases economic growth by 0.36%.

Table 5: Long Run Dynamic

*Coint eq = gdp - (0.4565*LCS + 0.3629*LTAP + 3.7213)*	
Variable	**Coefficient**
CS	*0.4565* *(0.0000)**
TAP	*0.3629* *(0.0000)**
C	*3.7213* *(0.0000)**

*Note: * shows significance at 5% level.*

Source: Author's computation from E-View 9.0

The error (equilibrium) correction term (ECT) coefficient gives an idea about the speed of the adjustment, which restores equilibrium in the dynamic model and corrects the disequilibrium of the system. The ECT should be statistically significant and negative.

The results of the short-run model (presented in table 6) show that the error correction coefficient ECT(-1) is negative and significant at 5% level, so there is an error correction mechanism. The ECT coefficient 0.21 implies that deviations from the long-term growth rate in GDP are corrected by 0.21% (that mean the speed of adjustment is 21%). Both of CS and TAP has a positive and significant effect on economic growth in the short-run.

Table 6: Short Run Dynamic

Variable	*Coefficient*
D(CS)	*0.2663* *(0.0000)**
D(CS(-1))	*-0.1208* *(0.0000)**
D(TAP)	*0.0776* *(0.0140)**
ECT(-1)	*-0.2139* *(0.0020)**

*Note: * shows significance at 5% level.*

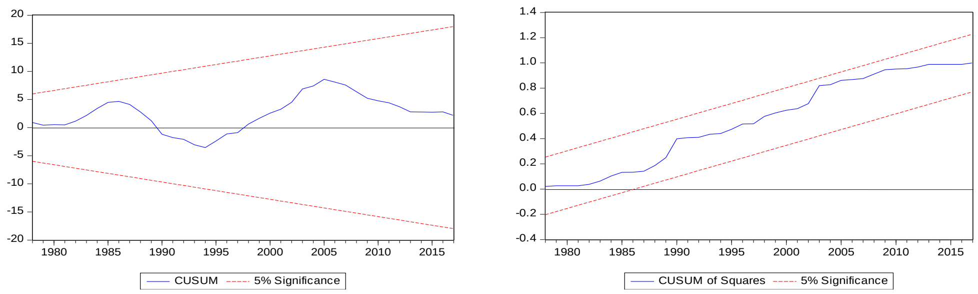
Source: Author's computation from E-View 9.0

3.6 PARAMETERS STABILITY TEST

The existence of a co-integration relationship between the variables does not necessarily imply that the estimated coefficients are stable. If the parameters are not stable, the result is irrelevant. This is why Brown, Durbin and Evans, 1975 introduced CUSUM (cumulative sum) and CUSUM of square tests which plot the CUSUM and CUSUMSQ together with the 5% critical lines.

Figure 2 shows the graph of CUSUM and CUSUMSQ. The test clearly indicates the stability of the parameters because the cumulative sum and the cumulative sum of squares are within the 5% significance lines, suggesting that the residual variance is stable.

Figure 2: CUSUM and CUSUMQ tests



Source: Author's computation from E-View 9.0

3.7 CONTRIBUTION OF TFP AND PRODUCTION FACTORS ON GDP GROWTH

As Table 7 shows that the average growth rate of GDP is 3.59 % between 1970 and 2018. During this period, the capital stock grew at an average of 3.53% a year, the total active population grew at 4.01% per year, and TFP grew at 1.01% per year.

Table 7: Average growth rates in Algeria (%) 1970-2018

GDP	Capital stock	Total active population	TFP
3.59%	3.53%	4.01%	1.01%

Source: Author's computation from Excel

Regarding the contribution of TFP and production factors to economic growth, we take ratios of factor growth rates and TFP to growth rates of total GDP (according to equation 1) weighted by production elasticities (Table 5).

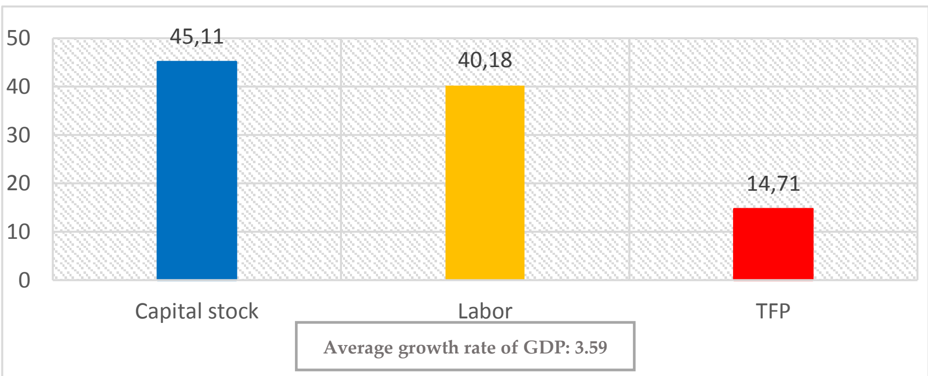
Table 8 and figure 3 present the components of GDP: 45.11% of GDP growth was due to growth in capital stock, 40.18% was due to growth in the total active population, and 14.71% was due to growth in TFP.
These results conform to the theory of exogenous growth. For Solow, in the long-run, economic growth cannot be explained by increasing labor and capital only, but it is technical progress that contributes to economic growth along with labor and capital. However, this one is exogenous to the model.

Table 8: Contribution of TFP and production factors on GDP growth (%) 1970-2018

Contribution of Capital stock	Contribution Total active population	Contribution of TFP
45.11%	40.18%	14.71%

Source: Author's computation from Excel

Figure 3: Contribution of TFP and production factors in GDP growth (%) 1970-2018



Source: Author's computation from Excel

4. CONCLUSION

The main objective of this study was to estimate the contribution of total factor productivity and find the main source of economic growth in Algeria from 1970 to 2018. Despite the lack of adequate data and the limitations of estimating TFP (measurement errors in output, labor, and capital can lead to errors in calculating productivity), our results are robust enough to draw the following main conclusions.

Results of the analysis in this paper finds that both the stock of real physical capital and labor force are important sources of economic growth in Algeria and support the positive and significant link between these factors and GDP in the long-run.

It can be clearly seen that the source of overall growth in Algeria has been driven mainly by factors accumulation: physical capital stock with 45.11% of contribution and labor force with 40.18% of contribution and then by technology (14.71% of contribution), which make our economic growth more extensive than intensive.

TFP is growing at a very low average rate of 1.01% per year and its contribution to Algeria's economic growth remains disappointing despite major efforts to improve and upgrading the technological level.

When looking at the TFP growth experiences of other countries, one finds that factors such as human capital development, physical capital development (including infrastructure), financial development, technology absorption, and openness (especially in terms of openness to imports and in terms of foreign direct investment (FDI) attraction policies) have a significant impact on TFP growth. Until Algeria focuses on these issues, growth will remain unsustainable.

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