The impact of Information & Communication Technology and Research & Development on economic growth in Algeria during the period (1990-2022)

أثر تكنولوجيا المعلومات والاتصالات والبحث والتطوير على النمو الاقتصادي في الجزائر خلال الفترة (1990-2022)

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Abstract:

This research aim to analyze and measure the impact of Information & Communication Technology and Research & Development on economic growth in Algeria during the period (1990-2022). We used the ARDL model, as result we find that is there is a long-run relationship between the variables. However, none of the following variables has a significant impact on economic growth in Algeria: mobile cellular telephone subscriptions, internet users, patent applications, or scientific and technical journal articles. We find that there is a positive and significant short-run relationship between the number of articles, mobile subscriptions, and economic growth.

Key words: ICT, R&D, economic growth, ARDL, Algeria.

المستخلص:

يهدف هذا البحث إلى تحليل وقياس أثر تكنولوجيا المعلومات والاتصالات والبحث والتطوير على النمو الاقتصادي في الجزائر خلال الفترة (1990-2022). استخدمنا نموذج ARDL ونتيجة لذلك نجد أن هناك علاقة طويلة المدى بين المتغيرات. ومع ذلك، لا تؤثر أي من اشتراكات الهاتف الخلوي المحمول ومستخدمي الإنترنت وطلبات براءات الاختراع ومقالات المجلات العلمية والتقنية على نمو الاقتصاد في الجزائر. نجد أن هناك علاقة إيجابية ومهمة على المدى القصير بين عدد المقالات واشتراكات الهاتف المحمول والنمو الاقتصادي.

الكلمات المفتاحية: تكنولوجيا المعلومات والاتصالات، البحث والتطوير، النمو الاقتصادي، ARDL ، الجزائر.

1. INTRODUCTION

Starting from the nineties of the last century, interest in technological development increased and tried to link it to various sectors, especially economic as it is the interface for all countries in the world.

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Therefore, Algeria tried to keep pace with these developments, especially after it witnessed during colonialism and its attempt to rise again, so it began to try to adopt everything new and pioneering, starting from the mobile phone, then the Internet, to scientific articles and patents, with the aim of dispensing with dependence on the Nordic countries. By mentioning dependency, we do not mean only cultural, but also economic dependence, so the availability of appropriate tools guarantees you outputs and effective solutions to various problems, but also avoids those problems.

In order to measure the extent of the development of the economy and get rid of dependence, economic growth must be measured year by year. Based on World Bank data, we find fluctuations in values, where we notice, for example, that in 2014 it reached $ 5516.26 and fell again in 2015 to reach 4197.40.

Some literature search the effect and the relationship between the ICT and R&D in economic growth they found that there is No uniform effect of ICT. Watanabe et al. (2015) found that there is a polarization in the GDP growth rates of "ICT developing countries "and "ICT developed countries". They believe that ICT progresses had a positive impact on innovation and economic modernization in economies with developed ICT, but had no impact on economies with advanced ICT. They attribute this to ICT growth. Rapid economic development in countries has promoted wider access to and normalization of ICT, creating a degree of level playing field.

Batuo (2015). Using a sample of 44 African countries over the period 1990 through 2010. It found that investment in ICT is subject to increasing returns. This indicates that increased investment in ICT leads to increased growth based on GMM and OLS models. Her results indicated that GDP per capita increases between 0.5% and 0.8% after increasing telephone density by 10 persons per 100 inhabitants, indicating the positive contribution of telecommunications to economic growth in Africa.

Other study of Nailul Huda, Izzudin Al Farras Adha, Siti Rizqi Ashfina R. S. (2020). Search the impact of R&D spending in the five ASEAN countries and four major Asian countries during the period using 5 different estimation methods and concluded that R&D spending has a positive and statistically significant impact on economic growth in those nine countries, most of which are developing countries. We also show that the control variables (investment, FDI, patents, GDP, and employment) are significantly associated with economic growth. Based on the result of the five regression methods, the government needs to increase R&D spending through tax incentives because tax incentives have a positive and significant effect on R&D spending.

Later authors included R&D as a central factor in growth and modified Solow's (1956) neoclassical growth model, which considered productivity, capital accumulation, and population growth as the main sources of economic growth. Griliches (1979) advanced the idea that productivity growth is the result of R&D expenditures. In Romer's (1986) endogenous growth model, firms' R&D expenditures lead to an increase in aggregate output because private R&D generates spillover effects through its contribution to the public stock of knowledge1. One of the foundations of economic growth is R&D expenditure, because technological change is the result of conscious economic investment, and sustainable growth cannot achieved without an impact on R&D. (Grillices, 1992).

Goel and Ram (1994), in their study covering 52 countries for the period 1960-1980, found that there is a significant relationship between R&D expenditures and economic growth in the long term; however, the direction of causality between the variables could not be determined.

Those results make us try to find the impact of ICTs and R&D on economic growth in Algeria.

We want to study the causal relationship and try to build a model that allows us to know the impact of various variables on economic growth.

1.1. Problem of the study

This leads to the following research question:

Do ICT and R&D have an impact on economic growth in Algeria?

For finding an answer for the previous question, we need to ask some other questions:

We need to know the meaning of ICT and R&D.

Is there a relationship between both of ICT, R&D and economic growth?

1.2. Hypotheses

- There is a long-run relationship between both of ICT, R&D and economic growth.
- There is a significant impact for each of mobile operators and Internet users and both of the number of patents and number of articles.

1.3. Study importance

All of us know the fact that the whole world is now moving to dispense with traditional methods in various fields, especially economic ones, so it is necessary to keep pace with these changes and also the fact that modern technological methods give quick and more effective solutions .

1.4. The objectives of the study

The main objective of our study is to find the impact of ICT and R&D on the economic growth and find the relationship between the ICT, R&D and economic growth in Algeria.

1.5. The Empirical Methodology

The descriptive approach was used by giving theoretical concepts to the study variables. as we used the econometric methodology to find the model.

For this purpose, the study was formed as follows:

In the first section we have the introduction, in the second section we examined literature

related to the study in the third section the Establishing the theoretical aspect of the various variables is presented, in the fourth section we introduced the dataset and building an economic model that studies the relationship between the variables of the study. In conclusion policy proposals

were presented.

2. The theoretical framework

2.1. Theoretical Framework:

2.1.1. Definitions of R&D:

Creative and methodological work carried out is one of the most important pillars of research and development with the aim of increasing the stock of knowledge.

R&D activities defined by, depending on their implementers. The R&D activities to be achieved may be specific or general objectives. With the aim of reaching new results, depending on the original concepts or hypotheses as for its final results they are highly uncertain, planned and budgetary, And as one of its many goals is for their results to be freely transferable and tradable in the market. But there must be five basic criteria in order to say that an activity is a research and development activity: systematic, transferable and/or repeatable, creative, and uncertain.

2.1.2. The definition of ICT[2]

There is no universally accepted definition of ICT. The concepts, methods and applications involved in ICT are constantly evolving on an automatically basis. A good way to think about ICT is to consider all uses of digital technology that already exists to help individuals.

The 'C' in ICT refers to the communication of data by electronic means, usually over some distance. This is achieved through networks that send and receive equipment. The 'I', on the other hand, refers to the data that has processed in such a way as to be meaningful to the person who receives it.

2.1.3. The definition of economic growth

2.1.3.1. The Direct Impact – A Neoclassical Model

First studies on economic growth are frequently used for the aggregate production function Approach [3]. They want to describe the relationship between economic output and primary inputs. The most important inputs are capital and labor. In particular, the seminal work of Solow (1956, 1957) laid the foundation for many applied growth these studies integrate aggregate production functions using macroeconomic data. In this case, the role of investment can summarized in the following two equations.

These equations express the total production function, which shows the relationship between production (Y), capital input (K), labor input (L) and the"Hicks-neutral"[4](A):

$$Y = A*f(K, L) \qquad [1]$$

$$\Delta Kt = It - \alpha\, Kt\text{-}1 \qquad [2]$$

2.2.3.2. Beyond the Direct Impact – The New Growth Theory

In order to achieve a developing economy, we must always focus on increasing the rate of savings (investment) will achieve A higher level of production than if it does not succeed in increasing it, and therefore it is necessary to grow faster for a However, sustained higher output growth will not be achieved. Therefore, the permanent growth rate of output per unit of labor input has nothing to do with the saving rate (investment), but depends entirely on the rate of technology [5].

The earlier studies of the New Growth School. The models generally assumed that returns are constant for the expansion of the range of inputs (i.e., capital and labor) and assumed that the level of technology depends on a set of inputs. For example, Arrow (1962) explained investing in tangible assets as generators of indirect effects, that is, technology is a direct function of capital. The model can write in this function5.[6]

$$Yi = A(K)*f(Ki, Li) \qquad [5]$$

3. Methodology

3.1.The study variables

Before trying to build the model, it's important to say that all the variables that we choose is theoretically accepted however negative or positive effect.

The variables that we choose is:

3.1.1. The indicators, which used:

Variables	Definition
RGDP: economic growth	GDP divided by the mid-year population. GDP is the sum of the gross value added by all producers residing in the economy plus all taxes on products minus any subsidies not included in the value of products. Calculated without deductions for depreciation of manufactured assets or for the depletion and degradation of natural resources Data are in current U.S. dollars.
MCS: mobile cellular subscriptions	Are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes (and is divided into) the number of postpaid subscriptions and the number of active prepaid accounts (used within the past three months). The indicator applies to all mobile cellular subscriptions that offer Voice communication. Subscriptions via data cards or USB modems, subscriptions to public mobile data services, trunk mobile radio, telepoint point, wireless pager and telemetry services are excluded.

INT: internet users	Are individuals who have used the Internet (from any location) in the last 3 months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.
PAT: patent applications, residents.	Are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention--a product or process that it offers a new way to do something or offers a new technical solution that will solve a problem. A patent that provides protection for the invention to the patent owner for a limited time, generally 20 years.
ART: scientific and technical journal articles	Refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

The source of our data was published by the World Bank data (https://data.albankaldawli.org/). Annual data for the Algerian economy were used in the analysis. (1990-2022).

3.2. Methods of Estimation:

To find the impact of ICT, R&D on economic growth in Algeria, we use the ARDL model developed by (Pesaran MH and Pesaran B, 1997)[7],(Pesaran and Shin, 1999)[8]and(Pesaran et al, 2001) (autoregressive distribution lag - ARDL). [9]

We have many Co-integration Tests. but we choose the Bounds Testing approach, cause of the others like test (Engle and Granger, 1987), and test (Johansen, 1988, 1991) and test (Johansen and Juselius, 1990) Requires variables to be integral of the same degree opposite of bounds test Also, these tests Results in inaccurate results if the number of views is small[10].

4. RESULTS AND DISCUSSION

4.1. Descriptive analysis of variables:

Table (1) below present's descriptive and statistical summaries of the variables.

Table 1. Descriptive Statistics

	RGDP	MCS	INT	PAT	ART
Mean	3188.347	53.34914	17.99839	80.57576	2253.551
Maximum	5610.733	116.6140	70.90000	310.0000	10345.00
Minimum	1466.545	0.001842	0.000000	6.000000	95.00000
Std. Dev.	1404.459	50.24616	23.33117	68.95652	2512.473
Skewness	0.246426	-0.002844	1.145181	1.700081	1.360222
Kurtosis	1.696971	1.143953	2.891434	6.074939	4.453735
JarqueBera	2.668584	4.736796	7.229122	28.89748	13.08198

Source: *Authors Computation with Eviews.12*

4.2. Unit root test for the variables:

Before estimate the model, we need to test the stationary of all the variables using ADF test, the results has been showed in the table 2 below.

Table 2. Results of unit root test (The Augmented Dickey-Fuller test)

Variables	At level			At first difference			Conclusion
	ADF statistic	Critical value	Result	ADF statistic	Critical value	Result	
RGDP	0.237941	-1.951687	No stationary	-5.086735	-1.952066	stationary	I(1)
MCS	0.487107	-1.952066	No stationary	-2.997025	-1.952066	stationary	I(1)
INT	1.790233	-1.952066	No stationary	-2.054669	-1.952066	stationary	I(1)
PAT	2.681771	-1.951687	No stationary	-3.705930	-1.952066	stationary	I(1)
ART	4.478323	-1.952473	No stationary	-3.393171	-1.952066	stationary	I(1)

Source: *Authors Computation with Eviews.12*

After doing the ADF test, all the variables which are (RGDP, MCS, INT, PAT, ART) become stable in the first difference and significant at 1%, 5% ,10% as shown in the table.

To estimate the ARDL model we must choose the best lag. The selection of lags follows the following criteria: from Akaike, Schwarz, and Hannan-Quinn, the results is in the table 3 below.

Table 3. VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: RGDP MCS INT PAT ART
Exogenous variables: C
Date: 12/12/23 Time: 11:09
Sample: 1990 2022
Included observations: 29

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-842.7694	NA	1.70e+19	58.46685	58.70259	58.54068
1	-683.5196	252.6031	1.67e+15	49.20825	50.62269	49.65123
2	-644.6088	48.30300	7.56e+14	48.24888	50.84203	49.06103
3	-585.1131	53.34101	1.15e+14	45.86987	49.64172	47.05116
4	-515.5264	38.39266*	1.81e+13*	42.79492*	47.74548*	44.34537*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: *Authors Computation with Eviews.12*

As a result ,the number of delay intervals following the variables P=4.

4.3. Bounds test results:

Table 4. ARDL Bounds test estimation results

Test Statistic	**Value**	**K**
F-statistic	**9.533614**	**4**
	Critical Value Bounds	
Significance	**I(0) Bound**	**I(1) Bound**
10%	**2.2**	**3.09**
5%	**2.56**	**3.49**
2.5%	**2.88**	**3.87**
1%	**3.29**	**4.37**

Source: *Authors Computation with Eviews.12*

The resulting F statisticis (F= 9.533614), which is greater than the upper I(1)and lower I(0) criticalboundariesatthe1%,2.5%,5%and10%levels.However,theycannotbeusedin this case. Because the sample is less than 80, so we use the (Narayan,2005)[11] critical value, (6.56, 5.514, 4.73, 3.922, 3.17) at level (1%, 2.5%, 5%, 10%). The Narayan critical value is less than F-Statistics. Thus and the null hypothesis was rejected. This suggests a long-term relationship between RGDP, INT, MCS, PAT, and ART .During the study period (1990 to 2022).

4.4. Long-run relationship equation:

Table 5. Long run equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
MCS	13.00469	10.78786	1.205494	0.2944
INT	-228.5537	107.0383	-2.135251	0.0996
PAT	-6.220120	6.031067	-1.031347	0.3607
ART	2.701293	1.655571	1.631638	0.1781
C	1090.487	296.8556	3.673459	0.0213

EC = RGDP - (13.0047*MCS -228.5537*INT -6.2201*PAT + 2.7013*ART + 1090.4866)

Source: *Authors Computation with Eviews.12*

as showed in the table 5 the variables MCS, PAT ART are not INT and constant are significant at level 10%,a one-unit increase in the value added of PAT and INT would a decrease in GDP 6.22012 and 228.5537 units respectively, this results its contrary to the economic theory.

This indicates the weak contribution of the Internet and patents to economic activity is because the patent is not applied on the ground, so it does not contribute to economic growth, and for the Internet, this is due to the fact that the Algerian economy does not depend on the digital economy or e-commerce.

On the other hand, MCS and ART contribute to raising the RGDP by 13,00469 units and

2,701293 respectively.

These results can explained by the fact that the use of ICTs (mobile phones and the Internet) is limited to personal use. It does not enter the production processes or even the field of services in a big way, as Algeria still uses traditional methods in most fields. We explain the insignificance of the scientific articles by the fact that the articles do not directly target the reality in the country under study. Most of the articles deal with social issues that do not affect the economic growth of these countries. It can also explained by the fact that the outputs and recommendations of these articles not applied on the ground, so we do not see a tangible impact of these outputs.

4.5. Short-run relationship equation:

Table 6. short-run equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2280.108	1517.216	1.502823	0.2073
RGDP(-1)*	-2.090908	0.849933	-2.460086	0.0697
MCS(-1)	27.19162	32.11937	0.846580	0.4449
INT(-1)	-477.8848	135.7721	-3.519758	0.0245
PAT(-1)	-13.00570	12.96319	-1.003279	0.3725
ART(-1)	5.648155	2.116537	2.668583	0.0559
D(RGDP(-1))	0.530869	0.646003	0.821775	0.4574
D(RGDP(-2))	-0.357368	0.574080	-0.622506	0.5673
D(RGDP(-3))	-0.584795	0.313241	-1.866920	0.1353
D(MCS)	33.49467	10.63943	3.148164	0.0346
D(MCS(-1))	13.31484	27.82255	0.478563	0.6572
D(MCS(-2))	41.21586	22.74563	1.812034	0.1442
D(MCS(-3))	30.72427	19.10333	1.608320	0.1830
D(INT)	-84.46423	99.19792	-0.851472	0.4425
D(INT(-1))	334.5693	130.4916	2.563913	0.0624
D(INT(-2))	-29.03891	113.1858	-0.256560	0.8102
D(INT(-3))	-241.1790	162.9233	-1.480323	0.2129
D(PAT)	0.780316	4.214834	0.185136	0.8621
D(PAT(-1))	9.014295	9.556295	0.943283	0.3989
D(PAT(-2))	8.361317	6.677329	1.252195	0.2787
D(PAT(-3))	3.580935	5.866429	0.610411	0.5746
D(ART)	1.208219	0.333228	3.625801	0.0222
D(ART(-1))	-1.987147	2.653597	-0.748850	0.4956
D(ART(-2))	0.662530	2.042740	0.324334	0.7619
D(ART(-3))	-1.647464	1.762036	-0.934977	0.4027

Source*: Authors Computation with Eviews.12*

From the table 6, we find that there is a positive and significant relationship between ART (-1), MCS, ART and RGDP. Which mean that the other variables does not affect.

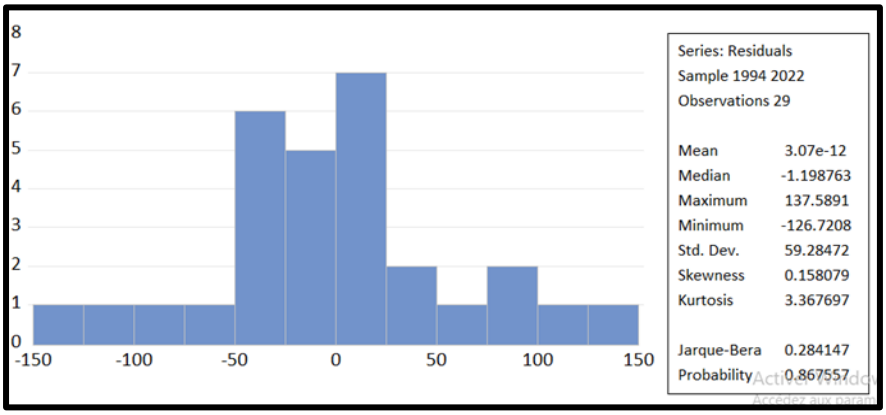
The results means that the ICT, R&D they only make an impact in the short term, This can be explained by the fact that technological development in Algeria is going slowly and not at the same pace, so we do not see the economic results of this development because, as great economic growth needs a great technological leap.

4.6. Diagnostic tests of the model:

In order to ensure that the chosen model is suitable we must do some diagnostic tests

4.6.1. Normality test:

Fig.1. Normality test



Source: *Authors Computation with Eviews.12*

Through the results of the above figure, we have the Jarque-Bera probability 0.28, is higher than 0.05. So, we accept the null hypothesis. So, the residuals follow the normal distribution.

4.6.2. Autocorrelation test:

To make sure that there is no serial correlation in the estimated model we use (Breusch-Godfrey LM test) the result chowed in the table (8) below

Table 7. Autocorrelation test

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	0.556910	Prob. F(2,2)	0.6423
Obs*R-squared	10.37336	Prob. Chi-Square(2)	0.0056

Source: *Authors Computation with E-view 12*

Through the results of the above table (7), we have the LM test probability (0.64) is higher than 0.05 so we accept the null hypothesis. So, there is no serial correlation in the model.

4.6.3. Heteroskedasticity test:

Table 8. Heteroskedasticity test

Heteroskedasticity Test: ARCH			
F-statistic	3.163000	Prob. F(1,26)	0.0870
Obs*R-squared	3.036862	Prob. Chi-Square(1)	0.0814

Source: *Authors Computation with E-view 12*

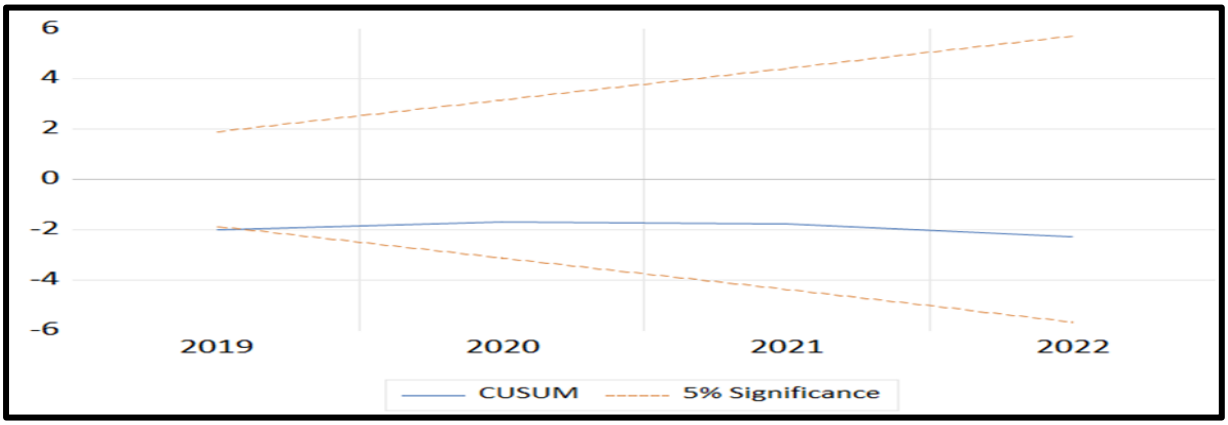
Through the results of the above table (8), we have the Arch test probability (0.08) is higher than

0.05 so we accept the null hypothesis. So, Error variance is constant.

4.6.4. Stability test of the model:

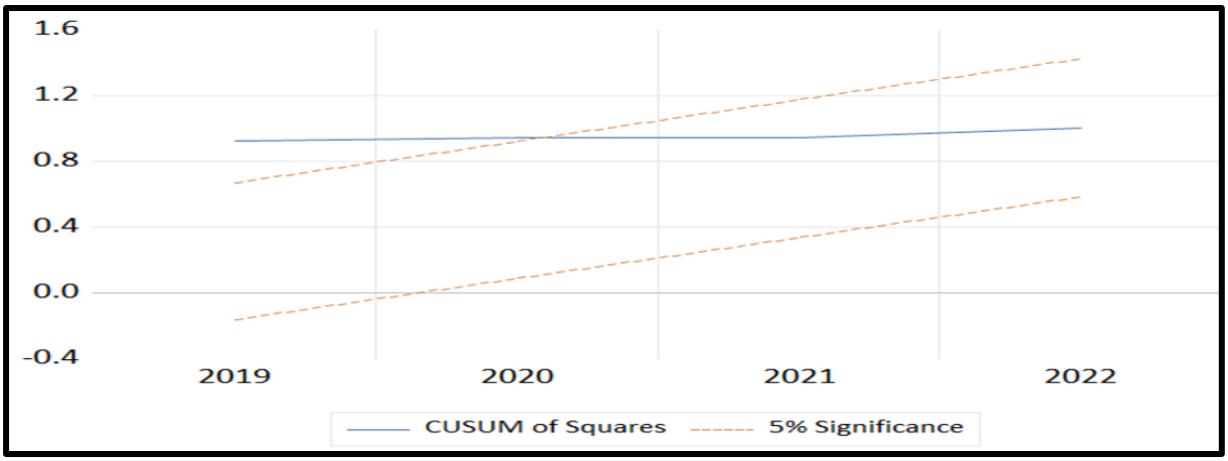
To ensure that there are no structural changes in the data , we must to do the **CUSUM** and **CUSUM OF SQUARES** test the result are showed in the Figures 3, 4 below.

Fig.2. Plot of CUSUM test



Source: *Authors Computation with E-view 12*

Fig.3. Plot of CUSUM-SQ showing stability of the Model



Source: *Authors Computation with Eviews.12*

The results in the figures how that the curve (CUSUM) is within the5%criticallimit,whilethe curve (CUSUM OF SQUARES) is not within the5%criticallimit..

5.CONCLUSION:

The paper objective. To study the effects of ICT and R&D on economic growth in Algeria A newly developed autoregressive distributed lag (ARDL) approach was employed to capture the short and long-run cointegration between TIC, R&D and economic growth variables. An autoregressive

distributed lag (ARDL) approach was employed to capture short-and long-term cointegration between TIC, R&D and economic growth variables. Annual time series data from 1990 to 2022wereusedintheanalysis. The results of this study are as follows:

1- After we estimate the model, we found that the ICT and R&D doesn't effect on the growth economy so we reject the third and fourth hypothesis.

2- We find that there is a positive and significant short-run relationship between ART(-1), MCS , ART and RGDP.

3- The need to care about other sectors and expanding the work of various technology tools and introducing them in all sectors and the outputs of scientific articles and patents must be applied to achieve better development results .

Margins:

(1)*: See Romer (1994) for a good review of endogenous growth models.*

(2)*: gherzouli ikhlas, https://www.asjp.cerist.dz/en/downArticle/4/8/2/12149*

(3) *:See Cobb Douglas (1928), Tinbergen (1942), and Solow (1956, 1957).*

(4)*: Following Hicks (1932), a technological innovation is Hicks neutral if the ratio of marginal product of capital to marginal product of labour is unchanged for a given capital to labour ratio. That is, Y = A*f(K,L)*

(5)*: Robert M. Solow (1987) in Nobel lectures, Economics 1981-1990, Editor Karl-Göran Mäler, World Scientific Publishing Co., Singapore*

(6)*: Adapted from Romer (1994) who simplified the evolution of the endogenous growth models.*

(7)*: Pesaran MH, Pesaran B. 1997. Working with Microfit 4.0: Interactive Econometric Analysis, Oxford University Press: Oxford.*

(8) *: Pesaran MH, Shin Y. 1999, An autoregressive distributed lag modelling approach to cointegration analysis, Chapter 11 in Econometrics and Economic Theory in the 20 th Century: The Ragnar Frisch Centennial Symposium, Strom S (ed.). Cambridge University Press: Cambridge.*

(9) *:Pesaran, M. H., Shin, Y., and Smith, R. J. (2001), Bound Testing Approaches to the Analysis of Level Relationships, Journal of Applied Econometrics, 16: 289–326*

(10) *:Pesaran et al, op.cit, p: 289–326*

(11) *:Narayan, P. K. (2005), The Saving and Investment Nexus for China: Evidence from Cointegration Tests, Applied Economics. 37(17): 1979-1990*