Energy Consumption and Economic Growth in Algeria Econometric Study

استهلاك الطاقة والنمو الاقتصادي في الجزائر دراسة قياسية

TAOUCHE Kandouci[1], **LAHOUAL Benali**[2]

[1] SAIDA University laboratory ITMAM (ALGERIA), tkandouci@univs.dz

[2] SAIDA University laboratory ITMAM (ALGERIA), labenali@univs.dz

Received: 27/08/2019 *Accepted: 23/11/2019* *Published: 01/01/2020*

Abstract:

This article aims to analyse the relationship between energy consumption and economic growth in Algeria for the period 1980-2014 using ARDL methodology to determine its implications in terms of economic policies; the empirical results confirm the presence of a long-term relationship between economic growth and per capita energy consumption per capita; in addition, the estimated long-term relationship shows a 1% increase in per capita economic growth led to an increase of 2.10% of the energy consumption per capita.

Moreover, Toda Yamamoto causality test indicates the existence of a unidirectional causality in the sense of per capita economic growth to energy consumption per capita, in other words, more economic growth leads to increased energy consumption.

Keywords: Consumption Energy; Economic Growth; ARDL Model; Co integration.

JEL Classification Codes: N77, O41, C32

ملخص:

يهدف هذا المقال إلى تحليل العلاقة بين استهلاك الطاقة والنمو الاقتصادي في الجزائر للفترة 1980-2014 باستخدام منهجية *ARDL* لتحديد آثارها من حيث السياسات الاقتصادية وتؤكد النتائج التجريبية وجود علاقة طويلة الأجل بين النمو الاقتصادي ونصيب الفرد من استهلاك الطاقة للفرد الواحد وبالإضافة إلى ذلك، فإن العلاقة المقدرة على المدى الطويل تظهر زيادة بنسبة 1٪ في النمو

***Corresponding author**: TAOUCHE Kandouci, **e-mail:** tkandouci@yahoo.fr*

الاقتصادي للفرد الواحد أدت إلى زيادة بنسبة 2.10٪ من استهلاك الطاقة للفرد الواحد .وعلاوة على ذلك، يشير اختبار السببية في (Toda Yamamoto) إلى وجود سببية أحادية الاتجاه.بمعنى النمو الاقتصادي للفرد الواحد في استهلاك الطاقة للفرد الواحد، وبعبارة أخرى، فإن زيادة النمو الاقتصادي تؤدي إلى زيادة استهلاك الطاقة.

الكلمات الرئيسية: استهلاك الطاقة; النمو الاقتصادي؛ منهجية *ARDL*; التكامل المشترك

تصنيفات JEL: N77, O41, C32

1. INTRODUCTION

The Algerian economy is based mainly on the exploitation of hydrocarbons, almost unique resource of the country, they are the country's main source of income (98% of revenues of Algerian exports), hydrocarbon revenues have funded different economic stimulus programs and significantly reduce the external debt of the country, and our article is to answer the following questions:

Is there a cointegration and causal relationship between energy consumption and economic growth?

2. Theoretical part:

2.1 Introduction

Energy is considered a basic material needed for human and economic life. Nowadays, it has become increasingly important due to its use in the majority of economic and non-economic activities. The energy sector offers several finished products such as electricity, liquefied petroleum gas, natural gas, gasoline, diesel and heavy fuel oil, necessary for everyday household life (transport, cooking, heating, and lighting) and for corporate production activity.

To design energy efficient power saving policies, we need to know the impact of energy consumption on economic growth.

2.2 **Overview of theoretical and empirical studies from the energy consumption and economic growth:**

The subject of the causal relationship between energy consumption and economic growth has been well studied in the literature of energy saving, which subdivides it into two categories : the first is the one that shows the relationship between the energy consumption and economic growth in the case of time series, and the second is dealing with this relationship in the presence of panel data. Among the pioneering studies of economic energy-growth relationship, we quote that of Kraft and Kraft (1978) for the case of the United States (Kraft & Kraft, 1978, p. 401). Subsequently, empirical studies have increased leading to a variety of empirical results and sometimes opposite either because of different time periods or different variables used or the sample of countries studied or because of different econometric methodologies applied. This divergence of causality results between energy consumption and economic growth has had important economic and energy implications.

The nature of the causal relationship is of major importance for the design and effective implementation of economic and energy policies (Ozturk, 2010, p. 342). Indeed, the countries for which energy is an independent variable (that is to say the countries for which the causality tends energy consumption to economic growth) will have a prudent energy policy because anyone any negative shock to their energy supply will exert a negative impact on economic growth. On the contrary, in an economy where energy consumption is determined by economic growth (that is to say, the direction of causality tends economic growth to energy consumption), the political economy of energy would have a very small effect on economic growth (Ouedrago, 2010, p. 526).

At this level, the focus ofart work is based on the approach of co-integration and Granger causality as a method of analysis of the causal relationship between energy consumption and economic growth for one country. The most interesting studies are listed in Table1 (بن محاد, 2017, p. 159); (Cherif, 2011, p. 247); (Tsani, 2010, p. 585); (Fondja, 2013, p. 1300) (Liang & Liu, 2013, p. 317); (Soares, Kim, & Heo, 2014, p. 60); (Tang, Tan, & Ozturk, 2016, p. 1510). The results found by Ben Mouhad (2017) for the case of Algeria for the period 1980-2015, applying the cointegration test and its validity and the Granger causality test indicates the presence of a unidirectional causal relationship from of energy consumption to economic growth (real GDP). By cons Cherfi study (2011) found no conitégration of relationship between the two variables, but there is a unidirectional causality from economic growth to energy consumption. The results found by Tsani (2010) for the case of Greece for the period 1960-2006, applying the methodology of Toda and Yamamoto indicate the presence of a unidirectional causal relationship from energy consumption to economic growth (real GDP) for Greece. For its part, Fondja Wandji (2013) studied the nature of the relationship between energy consumption and economic growth for Cameroon through a tiered approach: (i) the study of stationary, (ii) the causality test between the variables studied and (iii) estimating the appropriate model. Granger causality test indicates a strong unidirectional evidence ranging from oil to real GDP.

The co-integration test shows that the two series are cointegrated. The application of the model VECM shows that an increase in consumption of petroleum products by 1% would generate an increase in economic growth of 1.1%. This result implies that an economic policy aimed at improving the energy supply will necessarily have a positive impact on economic growth. On another side, lack of energy is a bottleneck for further economic development in Cameroon. Similarly, Liang and Liu (2013) point out the existence of a long-term cointegration relationship between energy consumption and economic growth in the case of China over the period 1953-2008, and using the technical cointegration and VECM model. For their part, Soares et al. (2014) note that energy plays an important role in economic development and poverty reduction. To analyze the relationship between energy consumption and economic growth (real GDP), these authors applied the VECM model and Granger causality test to the case of Indonesia. The results found show no long-term causal relationship; while in the short term, a bidirectional relationship has been detected. The empirical results thus suggest the possibility of reducing the energy requirement for a certain level of real GDP without the need to increase the use of other factors of production. This implies that the energy saving can be considered as an effective policy tool to reduce production costs and a more competitive Indonesian economy. Finally, we mention the recent work of Tang et al. (2016) which deals with the relationship between energy consumption and economic growth for the case of Vietnam using the Solow neoclassical growth model over the period 1971-2011. The methodology of cointegration and causality has been studied to determine the relationship between the variables of interest. The results of this study indicate the existence of cointegration between the variables. In particular, energy consumption, foreign direct investment (FDI) and capital stock have a positive impact on Vietnam's economic growth. Granger causality test indicates a unidirectional relationship from energy consumption to economic growth. Therefore, Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. energy consumption, foreign direct investment (FDI) and capital stock have a positive impact on Vietnam's economic growth. Granger causality test indicates a unidirectional relationship from energy consumption to economic growth. Therefore, Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. energy consumption, foreign direct investment (FDI) and capital stock have a positive impact on Vietnam's economic growth. Granger causality test indicates a unidirectional relationship from energy consumption to economic growth. Therefore, Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. Granger causality test indicates a unidirectional relationship from energy consumption to economic growth. Therefore, Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. Granger causality test indicates a unidirectional relationship from energy consumption to economic growth.

Therefore, Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth. Vietnam has an "energy-dependent" economy and any environmental policy developed to conserve energy would jeopardize the process of economic development in Vietnam. For this reason, a renewable energy policy should be put in place to ensure adequate energy supplies for accelerating economic growth.

Table 1: Summary of recent empirical studies on the direction of causality between energy consumption and economic growth

authors	Period	Country	Methodology	causality
Ben mohad Samir (2017)	1980-2015	Algeria	cointegration test, Granger causality test	PIBCE→
Cherfi souhila (2011)	1965-2008	Algeria	cointegration test, Granger causality test	PIBCE→
Tsani (2010)	1960-2006	Greece	Toda and Yamamoto of Methodology	CEPIB→
Fondja Wandji (2013)	1977-2009	Cameroon	cointegration test, Granger causality ECM model	CEPIB (EC: oil)→ EC-GDP (EC: electricity) EC-GDP (EC: Organic Fuel)
Liang and Liu (2013)	1953-2008	china	cointegration test, VECM, Granger causality test	PIBCE (short term)↔ GDP-EC (long-term)
Soares et al. (2014)	1971-2008	indonesia	cointegration test, VECM, Granger causality test	PIBCE (short term)↔ GDP-EC (long-term)

Tang et al. (2016)	1971-2011	Vietnam	cointegration test, VECM, Granger causality test	CEPIB→

Source: Prepared by the author.

Notes:

CEPIB: energy consumption due to economic growth.

PIBCE: economic growth because of energy consumption.

CEPIB: two-way causality between energy consumption and economic growth.

EC-GDP: lack of causality between energy consumption and economic growth.

THIS: Energy consumption, GDP: Gross domestic product

VAR: (Vector autoregressive model): autoregressive model vectors, ECM (Error Correction model) model for error correction,

VECMm (Vector error correcting model): template vectors with error correction.

3. Empirique parte:

3.1 Data and variables:

Data from the study are the comments on the primary level of energy consumption and the indoor production real Gross, during the period 1980-2014; This information is from the World Bank database.

The variables used are:

GNIPC: Production real Gross Domestic per capita expressed in constant 2010 US $.

CEH: Energy Consumption per Capita, expressed in Kg per capita oil equivalent.

Table 2: Descriptive characteristics

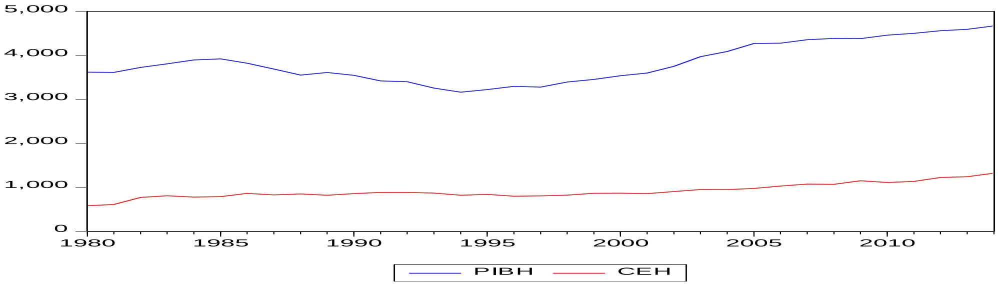
Observations	**GNIPC**	**CEH**
Mean	3834.366	913.6471
Median	3729.257	863.7872
Maximum	4675.885	1321.099
Minimum	3164.899	579.4516
Std. Dev.	452.4925	166.1113
Skewness	0.390030	0.602066

Kurtosis	**1.880198**	**3.159407**
Jarque-Bera	2.716072	2.151543
Probability	**0.257165**	**0.341035**
Sum	134202.8	31977.65
Sum Sq. Dev.	6961481.	938160.5
GNIPC	1	
CEH	**0.804**	1

Source: Prepared by the author from Eviews 10

Note that there is a strong positive correlation between the two variables.

Figure 1: *Graphical Overview of variables*



Source: Prepared by the author from Eviews 10

Table 3: unit root test of ADF and PP

	Test Augmented Dickey Fuller (ADF)			**Phillips Perron test (PP)**		
Variables	(1) in level	(2)	(3)	(1) in level	(2)	(3)
LBIPH	-0.689107	-0.391599	1.003124	-1.106452	-0.234578	1.082003
LCEH	-2.442260	-1.377605	2.615061	-2.607255	-1.385785	2.615061
	In the first Difference			In the first Difference		
Δ LBIP	-3.288389	-3.096677 *	-2.930695 *	-3.324541	-3.159364 *	-2.951675 *

Δ LCEH	-5.266137 *	-5.362947 *	-4.637644 *	-5.253096 *	-5.352800 *	-4.585462 *

Source: Prepared by the author from Eviews 10

Note: * indicates a significant level of 5%

(1), (2), (3) to indicate model (with constant and trend), (with only constant) and (without constant and without trend).

The results of the unit root Dickey Fuller and Phillips-Perron shown in Table 3 above, confirm that the two variables are stationary in the first difference, are thus integrated of order 1 or I (1).

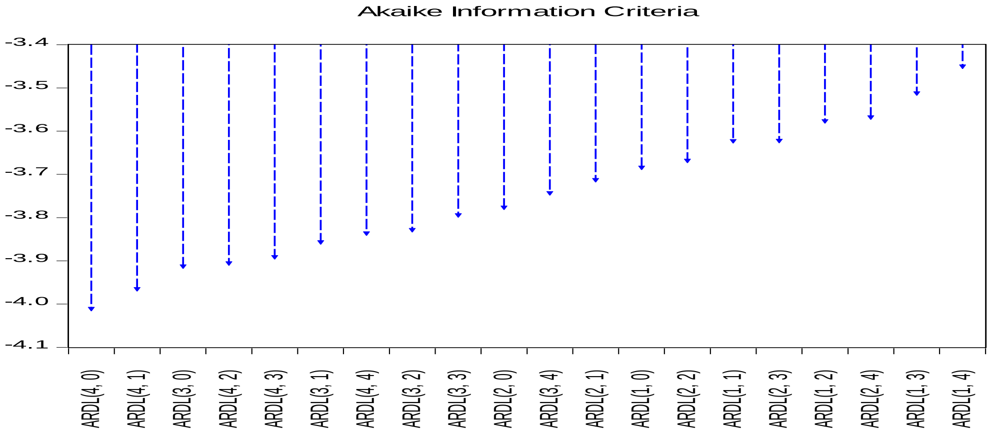
Based on the unit root test above, we apply the model developed by ARDL Pesaran and Shin (1999), which had an extension through Pesaran et al. (2001). The use of this model is justified by the fact that it takes into account both short-term relationships and those of long-term variables tested, it allows estimation of small sample sizes and also level variables different integration (I (1) and I (0)).

First, one starts by determining the optimum number of delay of each variable depending on the model, and AIC are used (Akaike Information Criterion) for this step.

3.2 Determination of optimal number of delays:

1st case LPIBH dependent variable:

Figure 2:*Akaika information*

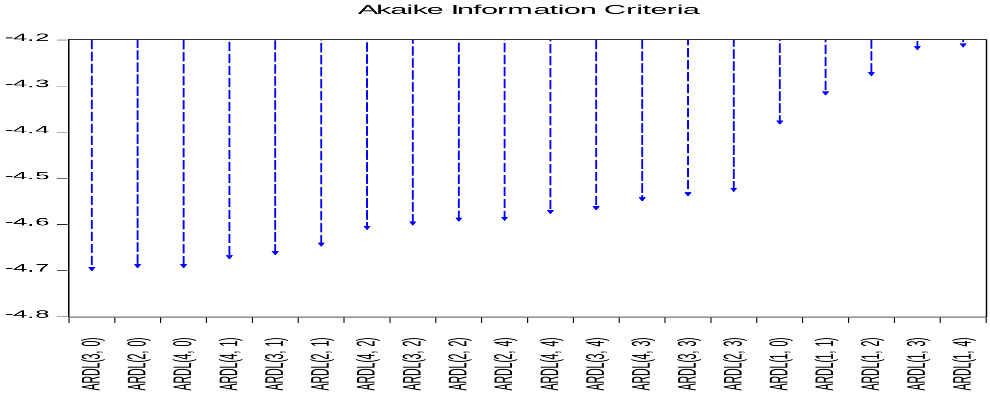


Source: Prepared by the author from Eviews 10

From the above graph (based on Akaike information criterion), the model ARDL (4, 0) is the best model.

2nd case LCEH dependent variable:

Figure 3: *Akaika information*



Source: Prepared by the author from Eviews 10

From the above graph (based on Akaike information criterion), the model ARDL **(3, 0)** is the best model.

3.3 Estimated ARDL model and cointegration test for both cases:

3.3.1 1st case LPIBH dependent variable:

3.3.1.1 The ARDL model:

Table 4: ARDL model

Variable	**Coefficient**		**Prob. ***
LPIBH (-1)	1.373045		**0.0000**
LPIBH (-2)	-0.248472		0.4316
LPIBH (-3)	-0.241204		0.2117
LCEH	0.078345		0.1291
C	0.427625		0.2135
R-squared	**0.973120**	Mean dependent var	8.248988
Adjusted R-squared	**0.969138**	SD dependent var	0.121111
F-statistic	**244.3664**	Durbin-Watson stat	**2.213926**
Prob (F-statistic)	**0.000000**		

Source: Drawn from Eviews 10.

The estimation results show that LPIBH variable (-1) is statistically significant.

The quality of fit of the model is 97%, that is to say the total variability of GDP Per capita is explained by the 97% variable itself delayed by a year.

The Fisher statistic associated (244.36) is much greater than the value read in the Fisher table at the 5% threshold, according to the estimation results, the model is acceptable.

3.3.1.2 Cointegration test (test Bounds)

Table 5: Cointegration test

F-Bounds Test		Null Hypothesis: No relationship levels		
test Statistic	**Value**	**Sig.**	**I (0)**	**I (1)**
F-statistic	**1.095513**	10%	**3.02**	**3.51**
K	1	5%	**3.62**	**4.16**
		2.5%	**4.18**	**4.79**
		1%	**4.94**	**5.58**

Source: Drawn from Eviews 10.

The result of the procedure (test bounds) above shows that the Fisher statistic (1095) is lower than the lower bound for the different thresholds of significance.

So we accept the H0 hypothesis of no cointegration relationship.

3.3.2 2nd Case CE dependent variable:

3.3.2.1 the ARDL model:

Table 6: ARDL model

Variable	**Coefficient**		**Prob. ***
LCEH (-1)	0.288743		0.1221
LCEH (-2)	0.205079		0.2566
LCEH (-3)	0.056072		0.7060
LCEH (-4)	0.250119		**0.0459**
LPIBH	0.420401		**0.0003**
C	-2.067826		**0.0001**
R-squared	**0.966989**	Mean dependent var	6.836866
Adjusted R-squared	**0.960386**	SD dependent var	0.150169
F-statistic	**146.4630**	Durbin-Watson stat	**2.068091**
Prob (F-statistic)	0.000000		

Source: Drawn from Eviews 10.

The estimation results show that all the factors that have reported fat probabilities are statistically significant.

The quality of fit of the model is 96%, that is to say the total variability of EC per capita is 96% explained by the variable delay itself of 4 years and the GDP and constant.

The Fisher statistic associated (146.46) is much greater than the value read from the table of Fisher at the 5% threshold, according to the estimation results, the model is acceptable.

3.3.2.2 Cointegration test (test Bounds)

Table 7: Cointegration test

F-Bounds Test		Null Hypothesis: No relationship levels		
test Statistic	**Value**	**Sig.**	**I (0)**	**I (1)**
F-statistic	11.12620	10%	**3.02**	**3.51**
K	1	5%	**3.62**	**4.16**
		2.5%	**4.18**	**4.79**
		1%	**4.94**	**5.58**

Source: Drawn from Eviews 10.

The result of the procedure (test bounds) above shows that the Fisher statistic (11.12) is greater than the upper bound for the different thresholds of significance.

So we reject the H0 hypothesis of no long-term relationship and we conclude the existence of a co integration relationship between the two variables.

3.4 Estimated at correcting short-term error model:

Table 8: Estimated short-term

ARDL Error Correction Regression
Dependent Variable: D (LCEH)
Selected Model: ARDL (4, 0)
Case 2: Restricted Constant and No Trend

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient		Prob.
D (LCEH (-1))	-0.511271		**0.0021**
D (LCEH (-2))	-0.306192		**0.0063**
D (LCEH (-3))	-0.250119		**0.0336**
CointEq (-1) *	**-0.199986**		**0.0000**
R-squared	**0.517692**	Mean dependent var	0.015866
Adjusted R-squared	**0.464102**	SD dependent var	0.039287
Durbin-Watson stat	**2.068091**		

Source: Drawn from Eviews 10.

The estimation result shows that coefficient adjustment or restoring force is statistically significant, it is negative and is between zero and one in absolute value, which guarantees an error correction mechanism, and therefore the existence of a long-term relationship (cointegration) between variables, we also noticed that the consumption of energy delayed by a year, two or three years has a negative effect on the current energy consumption in the short term.

3.5 Estimated Long-term model:

Table 9: Estimated long-term

Variable	Coefficient	Prob.
LPIBH	2.102153	**0.0003**
C	-10.33985	**0.0191**

EC = LCEH - (2.1022 * LPIBH -10.3399)

Source: Drawn from Eviews 10.

The estimation result shows the long-term positive effects of economic growth on energy consumption; a 1% increase in per capita GDP accelerates energy consumption per capita of 2.1%, against the constant by a negative effect on long-term energy consumption.

3.6 Causality Test Toda-Yamamoto:

The causality test between energy consumption and economic growth according to the approach of Toda Yamamoto is in two stages. First, it is to determine the order of integration maximum (dmax) series and the optimal number of lags (p) of the VAR process. Then you have to estimate a VAR model increased level of order (p + d max), and therefore the application of the Wald test.

3.6.1Determining optimal number of VAR process

Table 10: VAR process

The G	LogL	LR	EPF	AIC	SC	HQ
0	61.42553	N / A	5.69e-05	-4.098312	-4.004016	-4.068780
1	125.1114	114.1953	9.29e-07	-8.214579	-7.931690	-8.125982
2	134.2260	**15.08621 ***	**6.57e-07 ***	**-8.567309 ***	**-8.095828 ***	**-8.419647 ***
3	137.8584	5.511249	6.82e-07	-8.541958	-7.881885	-8.335231
4	141.9704	5.671696	6.92e-07	-8.549681	-7.701015	-8.283889
5	142.5874	0.765986	9.08e-07	-8.316374	-7.279115	-7.991517
6	148.3033	6.307200	8.54e-07	-8.434712	-7.208860	-8.050790

Source: Drawn from Eviews 10.

To implement the causality test, we find that p = 2 and d max = 1; we redo the order process VAR VAR (p + d max).

Table 11: Wald test

Type causality	P + dmax	Stat. Wald	Proba.	Decision
LPIBH not cause LCEH	3	12.62866	**0.0055**	**Causality from economic growth to energy consumption (unidirectional causality)**
LCEH not cause LPIBH	3	3.316132	0.3454	

Source: Drawn from Eviews 10.

According to the result of causality in the above table confirms the existence of a long-term relationship between energy consumption and economic growth; the existence of a unidirectional causality from economic growth to energy consumption.

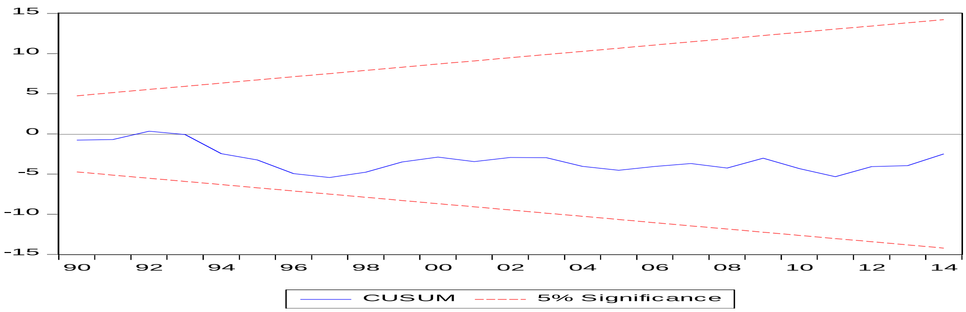
3.7 Stability of the model:

CUSUM tests are applied and CUSUMQ proposed by Brown, Durbin and Evans (1975). These tests are applied to model residuals; the CUSUM test is based on the sum of the residues. It shows the curve of the cumulative sum of the residues together with 5% of critical lines. Thus, the model parameters are unstable if the curve is outside the critical area between critical and stable lines if the curve is between two critical lines.

The same procedure is applied to achieve CUSUMQ test, which is based on the sum of squared residuals. The graphical representation of these two tests is applied to the selected template.

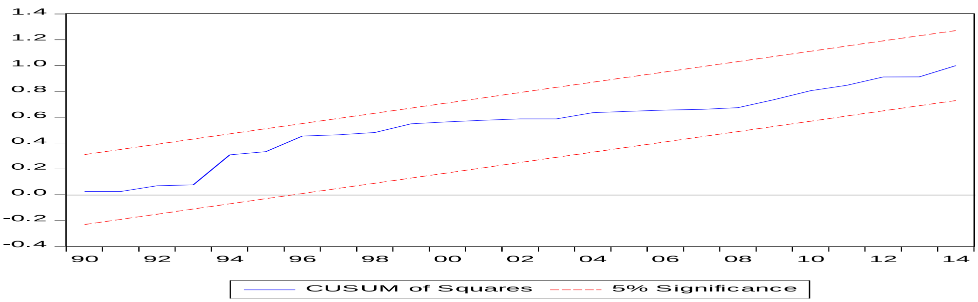
The two figures show the representation of the curve of the sum of residues and the square sum of the residue between critical lines indicating the stability of the model.

Figure 4: Curve of the running sum of the residues



Source: Prepared by the author from Eviews 10

Figure 5: Curve of the cumulative sum of squares of the residue



Source: Prepared by the author from Eviews 10

3.8 Validation of the model:

For the model to be valid, several tests are available including: the correlation test Breusch- Godfrey test Ramsey Reset, the JacqueBera of normality test.

Therefore, the probability of the correlation test Breusch- Godfrey obtained (0.7902) is much higher than 5%, demonstrating that the series retained in the model does not have correlation to each other, thus the likelihood of test JacqueBera equals 0.440> 0.05, therefore the model is normalized

3.9 Economic Interpretation of the results:

The estimation results of our model show that the causality between economic growth and energy consumption in Algeria is one way of economic growth to energy consumption, this result is confirmed by many recent studies among them, the study of Lee and Chang 2007 (Lee & Chang, 2007, p. 1215)of 18 developing countries and 22 developed countries; which found that the two-way relationship in developed countries, and the one-way relationship of energy consumption to economic growth for developing countries; and also the causal relationship to the study Mahara 2007 (Mehrara, 2007) of 11 oil exporting countries is one way of economic growth to energy consumption.

This study confirms the existence of a long-term relationship between the two variables, as CUSUM and CUSUMQ tests.

4. CONCLUSION

This study confirms that the energy consumption per capita does not participate in economic growth.

The absence of causality from energy consumption to economic growth; confirms that the contribution of energy consumption to economic growth in Algeria is low, and also because of the grant of the state in the energy sector.

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