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Energy Consumption and Economic Growth in Algeria: Cointegration and Causality Analysis

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ABSTRACT: This study investigates the energy consumption-growth nexus in Algeria. The causal relationship between the logarithm of per capita energy consumption (LPCEC) and the logarithm of per capita GDP (LPCGDP) during the 1965-2008 period is examined using the threshold cointegration and Granger causality tests. The estimation results indicate that the LPCEC and LPCGDP for Algeria are non cointegrated and that there is a uni-directional causality running from LPCGDP to LPCEC, but not vice versa. The research results strongly support the neoclassical perspective that energy consumption is not a limiting factor to economic growth in Algeria. Accordingly, an important policy implication resulting from this analysis is that government can pursue the conservation energy policies that aim at curtailing energy use for environmental friendly development purposes without creating severe effects on economic growth. The energy should be efficiently allocated into more productive sectors of the economy.

Keywords: Energy consumption; Economic growth; Cointegration; Granger causality.
JEL Classifications : C32; O13; Q41

1. Introduction

The causal relationship between energy consumption and economic growth has been extensively investigated since the seminal paper of Kraft and Draft in 1978. Different studies have done in different countries, time periods, and proxy variables using different econometric methodologies (Ozturk, 2010). However, evidences from empirical researches are still mixed and controversial in terms of the direction of causality and the intensity of impact on energy policy. Understanding the linkage between these two variables is extremely significant because energy policy implications mostly depend upon what kind of causal relationship exists. Bartleet and Gounder (2010) state that it's more important to know whether energy consumption causes economic growth than the case where either economic growth promotes energy consumption or no causal relationship exists between them.

The underlying reason of this justification is that it's really difficult for policy-makers to enact energy conservation policies if a country is known as energy-dependent. In the presence of such a relationship, any structural policies that aim at reducing energy consumption might possibly sloweconomic growth (Tsani, 2010).

Theoretically, an appropriate energy policy choice depends on the actual direction of the causal relationship between energy consumption and economic growth. Ozturk (2010) and Ozturk & Acaravci (2010) sum up four possible hypotheses about energy-growth nexus:

- Firstly, no causality between these variables is referred to as 'neutrality hypothesis'. In other words, energy is assumed to be neutral to growth. If this is not a case, conservative or expansive policies on energy consumption could adversely affect economic growth. Supporters of this view emphasize the role of substitution and technological progress. According to Belloumi (2009), the main reason for the neutral impact of energy on economic growth is that the cost of energy is negligible, so it is not likely to have a significant impact on economic growth. It has also been argued that the possible impact of energy consumption on growth will depend on the structure of the economy and the level of economic growth of the country concerned. As the economy grows, its production structure is likely to shift towards service sectors, which are not much dependent on energy (Solow, 1974; and Cheng, 1995).

- Secondly, uni-directional causality from economic growth to energy consumption supports the 'conservation hypothesis'. This implies that a country might implement the energy conservation policy without having any adverse effect on economic growth.

- Thirdly, uni-directional causality from energy consumption to economic growth is commonly considered as 'energy-led growth hypothesis'. Within this situation, policy makers should pay special attention on restrictions of energy use because this action may, to which extent, impede economic growth. Proponents of this hypothesis believe that energy is a critical input of production and plays as a complement to the basic factors of land, labour and capital. If this is a case, energy is said to be a limiting factor of economic growth (Stern, 1993; Cleveland *et al*., 2000).

- Finally, bi-directional causality between energy consumption and economic growth is known as 'feedback hypothesis'. This provides an insight that energy consumption and economic growth are jointly determined and affected together.

Chen *et al*. (2007) explain the mixed findings from previous studies are due to differences in not only data set, econometric approaches, but also countries' characteristics. For this reason, it's very dangerous to design future energy policy of one country based on experiences of others. Accordingly, a country-specific causality study between energy consumption and economic growth must be done to provide deep insights into design of energy policies. Therefore, what is the evidence for the Algerian energy development strategy that still provides special favour for energy sectors?

This research aims at answering the following questions: (1) Does long-term equilibrium exist between energy consumption and economic growth in Algeria? (2) Which of the above hypotheses is acceptable for the case of Algeria?

The remainder of this paper is organized as follows: Section 2 briefly reviews the literature on the energy-growth nexus. Section 3 presents the data and methodology used. Section 4 discusses the empirical results. We'll then provide the policy implications and give conclusions in Section 5.

2. Literature Review

The relationship between energy consumption and economic growth has been theoretically investigated through two main different approaches. In the neoclassical growth models, energy is simply considered as an intermediate input of production (Tsani, 2010). According to Bartleet and Gounder (2010), proponents of this view think that there are some mechanisms by which economic growth could remain in spite of a limited source of energy resources. The underlying explanation for this is built upon the possibility of technological change and substitution of other physical inputs for energy to use existing energy resources efficiently, and to generate renewable energy resources that are not subject to binding supply constraints (Solow, 1974, 1997; Stiglitz, 1997).

Accordingly, energy is merely one of the non-essential inputs in production process. In other words, the advocates of this theory support the 'neutrality hypothesis' and 'conservation hypothesis'. These hypotheses imply that energy supply restrictions might not have any harmful effect on economic growth. Thus, the government can simultaneously adopt the energy conservation and economic growth policies (Bartleet and Gounder, 2010).

On the other hand, the ecological economic theory states that energy consumption is a limiting factor to economic growth, especially in modern economies. Ecological economists judge that technological progress and other physical inputs could not possibly substitute the vital role of energy in production process (Stern, 1993, 2000). They even consider energy as the prime source of value because other factors of production such as labour and capital cannot perform without energy (Belloumi, 2009). The promoters of this perspective protect the so-called 'growth hypothesis', and hence, advise that any shock to energy supply will ultimately have a negative impact on economic growth. As a result, they are against the energy conservation policies.

Lots of empirical studies on energy consumption and economic growth nexus using different data set from different countries have so far provided various and contradictive results. The idea of causality between energy consumption and economic growth was first introduced in the seminal paper of Kraft and Kraft (1978) with the application of a standard version of Granger causality (standard Granger) test, which provided proof to support a uni-directional long-run relationship running from gross domestic product (GDP) to energy consumption for the USA over the 1947-74 period. This study suggests that government could pursue the energy conservation policies.

On the other hand, by employing the Sims causality technique, Akarca and Long (1980) showed no evidence of causality between energy consumption and GDP, so they criticized drastically the Kraft and Kraft's result in terms of the temporal sample instability. Since then, many academics have zealously joined the debate, but they have never reached the consensus (Belloumi, 2009). In the same manner, Yu and Hwang (1984) took up the Sims causality test with annual data and found no causality between energy consumption and GDP in the USA for the 1947-79 period. When using quarterly data with the same testing method, conversely, these authors discovered a uni-directional causality running from gross national product (GNP) to energy consumption in the USA for the 1973-81 period (Belloumi, 2009).

Yu and Choi (1985) employed the standard Granger causality test for the 1954-1976 period to explore the causal linkages between GNP and various types of energy consumption for a set of countries. Their empirical studies indicated that uni-directional causality running from economic growth to energy consumption for Korea, uni-directional causality running from energy consumption to income for the Philippines, while no causality existed in the USA, Poland and UK. Erol and Yu (1987) employed both Sims and Granger causality tests and found unidirectional causality from energy consumption to income for West Germany while bi-directional causality for Italy, and no evidence of causality for UK, Canada and France. Besides, they also uncovered the uni-directional causality running from energy consumption to economic growth for Japan over the 1950-1982 period.

On the contrary, when the sample was restricted to the 1950-1973 period, this causal relationship was no longer significant. Hwang and Gum (1992) used the cointegration and error correction model, and the bi-directional causal relationship between energy consumption and economic growth was observed in Taiwan for the period 1955-1993.

By using the cointegration and error-correction version of Granger causality test (ECM), Cheng (1995) realized the presence of uni-directional causality running from economic growth to energy consumption in India. In addition, Masih and Masih (1996, 1997) found the existence of cointegration between energy and GDP in India, Pakistan and Indonesia, but non-cointegration in Malaysia, Singapore and the Philippines. With the same data set, these authors applied the vector error correction model (VECM), and recognised a uni-directional causality running from energy consumption to income in India, a uni-directional causality running from economic growth to energy consumption in Indonesia, and bi-directional causality in Pakistan. This study also made use of the standard Granger causality test for the non-cointegrated countries (including Malaysia, Singapore and the Philippines), but did not find any Granger causality.

Glasure and Lee (1997) examined the causality between energy consumption and GDP for South Korea and Singapore and reported different results from different methodologies used. The standard Granger causality tests revealed no causal relationship for South Korea and a uni-directional causal relationship running from energy consumption to GDP for Singapore, while the ECM model gave signal of bi-directional causality for both countries. Cheng and Lai (1997) applied Hsiao's version of Granger causality to investigate the link between energy consumption and GDP for Taiwan for 1955– 1993 period. This study showed that causality runs from GDP to energy consumption without feedback in Taiwan.

Yang (2000) re-examined the causality between energy consumption and GDP for Taiwan using updated data for the 1954–1997 period. The finding of this paper totally denies the findings of Cheng and Lai (1997) of unidirectional causality from GDP to energy consumption. They found evidences of bi-directional causality between energy consumption and GDP.

Asafu-Adjaye (2000) tested the causal relationship between energy use and income in four Asian countries (including India, Indonesia, Thailand and the Philippines) using the ECM models. The test results indicated a uni-directional causality running from energy to income in India and Indonesia, and a bi-directional causality in Thailand and the Philippines. Aqeel and Butt (2001) used the ECM models to investigate the causal relationship between energy consumption and economic growth as well as between energy consumption and employment for Pakistan. The results inferred that economic growth caused total energy consumption.

Soytas and Sari (2003) studied causality between energy consumption and GDP for the G7 countries and for the top 10 emerging economies. Their research results found a bi-directional causality for Argentina, uni-directional causality running from GDP to energy consumption in Italy and Korea, and uni-directional causality running from energy consumption to GDP in Turkey, France, Germany and Japan.

Paul and Bhattacharya (2004) re-examined the direction of causality between energy consumption and economic growth in India by employing the ECM model for the 1950–96 period. As a result, they realized that a bi-directional causality existed between energy consumption and economic growth.

Besides, they also applied the Johansen cointegration testing approach and figured out the same direction of causality between energy consumption and economic growth. Altinaya and Karagol (2004) detected causality between the GDP and energy consumption in Turkey employing the Hsiao's version of Granger causality for the 1950–2000 period, characterized by structural break. The main conclusion of this study is that there is no evidence of causality between energy consumption and GDP in Turkey based on the detrended series.

Lee (2005) investigated the cointegration and the causality relationship between energy consumption and GDP in 18 developing countries, using data for the 1975–2001 period and employing panel unit root tests, heterogeneous panel cointegration and panel ECM models. The empirical results supported a long-run cointegration relationship between energy consumption and GDP after allowing for the heterogeneous country effects. The evidence illustrated that there were only long-run and short-run causalities running from energy consumption to GDP. This result suggested that energy conservation policies might, to which extent, harm economic growth in developing countries.

Wolde-Rufael (2005) ran a cointegration and a modified version of the Granger causality test to investigate the long-run and causal relationship between per capita GDP and per capita energy use for 19 African countries for the 1971–2001 period. Their results offered further evidence of the long-run relationship for eight out of the nineteen countries and causality for twelve out of nineteen countries.

Mehrara (2007) examined the causal relationship between the per capita energy consumption and the per capita GDP in a group of eleven oil-exporting countries (including Iran, Kuwait, Saudi Arabia, United Arab Emirates, Bahrain, Oman, Algeria, Nigeria, Mexico, Venezuela and Ecuador) by using panel unit root tests and panel cointegration tests. The test results found a uni-directional causality running from economic growth to energy consumption for these oil-exporting countries. Interestingly, the results recommened that energy conservation policies through reforming energy prices could not have any adverse effect on economic growth.

Chiou-Wei *et al*. (2008) conducted both linear and nonlinear Granger causality tests to examine the causal relationship between energy consumption and economic growth for a panel of Asian newly industrialized countries as well as the USA for the 1954–2006 period. Their study again supported a neutrality hypothesis for the USA, Thailand, and South Korea. Moreover, they unearthed the existence of a uni-directional causality running from economic growth to energy consumption for Philippines and Singapore while energy consumption might have negative effects on economic growth for Taiwan, Hong Kong, Malaysia and Indonesia. Chontanawat *et al*. (2008) tested for causality between energy and GDP using a consistent data set and Granger test for thirty OECD countries and seventy non-OECD countries. They discovered that causality running from energy to GDP appeared to be more prevalent in the developed OECD countries.

Tsani (2010) studied the causal relationship between aggregated and disaggregated levels of energy consumption and economic growth in Greece for the 1960–2006 period by using the methodology proposed by Toda and Yamamoto (1995). At the aggregated levels of energy consumption, the empirical findings suggested the presence of a uni-directional causality running from total energy consumption to real GDP.

At the disaggregated levels, the results indicated a bidirectional causal relationship between industrial and residential energy consumption to real GDP, and no causality between transport energy consumption and real GDP. The energy policy implication from these findings focused on the demand side and energy efficiency improvements in order to put less impact on economic growth.

Esso (2010) investigated the cointegration and causal relationship between energy consumption and economic growth in seven Sub-Saharan countries over the 1970–2007 period. This study used the Gregory and Hansen (1996b) threshold cointegration approach and the Toda and Yamamoto (1995) version of Granger causality test. The test results revealed that energy consumption was cointegrated with economic growth in Cameroon, Cote d'Ivoire, Ghana, Nigeria and South Africa in the presence of a structural break. Moreover, threshold cointegration test and ECM models suggested that economic growth had a significant positive long-run impact on energy consumption in these countries before 1988 while this effect was negative after the breakpoint, 1988, for Ghana and South Africa.

Furthermore, Granger-causality tests suggested a bi-directional causality between energy consumption and real GDP in Cote d'Ivoire and a uni-directional causality running from real GDP to energy consumption in the case of Congo and Ghana.

By using the recently developed autoregressive distributed lag (ARDL) bounds testing approach of cointegration and dynamic vector error correction (VECM) model for four Eastern European countries, Ozturk and Acaravci (2010) figured out that there is weak evidence about the long-run and causal relationships between energy consumption (or electric power consumption) and economic growth. Specifically, they found that evidence of cointegration and bi-directional strong Granger causality between these variables is only found in Hungary for the 1980-2006 period.

This study contributes not only the proof of causality, but the methodology used. The authors explained clearly the ARDL bounds testing approach used in the energy-growth linkage. In addition, Ozturk *et al*. (2010) employed the panel cointegration and causality analysis to investigate the differences in energy consumption and economic growth relationship among three groups of 51 countries classified as low income countries, lower middle income countries, and upper middle income countries for the 1971- 2005 period. The test results indicate that there exists cointegration between energy consumption and real GDP for all three income groups. From the panel causality tests, they conclude that there is a long-run Granger causality running from GDP to energy consumption for low income countries and bi-directional Granger causality between these variables for the other groups. Furthermore, these authors also provide evidence that there is no strong relation between energy consumption and economic growth in these countries.

Lau et al., (2011) re-examined the direction of causality and the sign (in the panel sense) between energy consumption (EC) and the GDP for seventeen selected Asian countries. Results reveal long-run stable equilibriums in these countries, while the EC brings about a positive impact on GDP. Causality runs from EC to GDP in the short-run, while the long-run causal linkage exists from GDP to EC. This indicates that energy is a force for economic growth in the short-run, but in the long-run, the EC is fundamentally driven by economic growth.

Farhani and Ben Rejeb (2012) applied panel unit root tests, panel cointegration methods and panel causality test to investigate the relationship between energy consumption, GDP and CO_2 emissions for 15 MENA countries covering the annual period 1973-2008. The finding of this study reveals that there is no causal link between GDP and EC; and between CO_2 emissions and EC in the short run. However, in the long run, there is a unidirectional causality running from GDP and CO_2 emissions to EC.

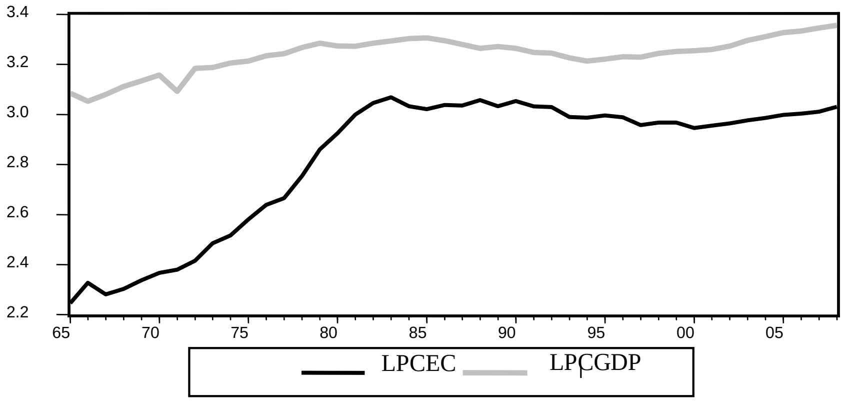
In summary, a general judgment is that the results are still mixed: that is, while some studies find causality running from economic growth to energy consumption, others figure out causality running from energy consumption to economic growth and even some studies suggest no causality and/or bidirectional causality between these two variables. The differences among these studies lie on the specific country characteristics, sample periods, research methodologies, and proxy variables.

3. Data and Methodology

3.1 Data Collection and Unit Root Tests

This paper uses the time series data of per capita GDP (LPGDP) and per capita energy consumption (LPCEC) for the 1965-2008 period in Algeria. Data are obtained from three sources: (i) the World Development Indicators (2009); (ii) Bp statistical review (2010); and the Algerien Office of Statistics. In this study, per capita energy consumption is expressed in terms of kg oil equivalent and per capita GDP is expressed in constant 2000 US$. It’s noted that all variables are transformed into natural logarithms in order to reduce heteroskedasticity and obtain the growth rate of the relevant variables by their differenced logarithms (Ozturk and Acaravci, 2010).

Figure 1. Algeria's per capita energy consumption and per capita GDP



In order to establish the order of integration of the variables concerned, this study first employs the conventional unit root tests widely known as the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Generally, a variable is said to be integrated of order *d*, written by *I*(d), if it turns out to be stationary after differencing *d* times. The variable is integrated of order greater than or equal to 1 is non-stationary. According to Asteriou and Hall (2007), most economic variables are cointegrated of order 1.

In testing for the existence of a unit root of the time series Y*t* (H0: δ = 0), we can select one out of the following three possible forms of the ADF test (Y*t* can be either LPCEC*t* or LPCGDP*t*):

$$\Delta Yt = \rho Yt{-}1 + \sum_{j=1}^{p} \varphi j \Delta Yt - j + \varepsilon t \qquad (1)$$

$$\Delta Yt = \rho Yt{-}1 + \sum_{j=1}^{p} \varphi j \Delta Yt - j + \varepsilon t + \alpha \qquad (2)$$

$$\Delta Yt = \rho Yt{-}1 + \sum_{j=1}^{p} \varphi j \Delta Yt - j + \varepsilon t + \alpha + \beta t \qquad (3)$$

The difference between the three regressions concerns the presence of the deterministic elements α and βt. For choosing the best one among the three equations, we will first plot the data (of each series) and then observe the graph because it can, to which extent, indicate the presence or not of the deterministic trend regressors.

Esso (2010) states a break in the deterministic trend affects the outcome of unit root tests because many previous studies have found that the conventional unit root tests fail to reject the unit root hypothesis for series that are actually trend stationary with a structural break. Perron (1989) showed that a Dickey and Fuller (1979) type test for unit root is not consistent if the alternative is that of a stationary noise component with a break in the slope of the deterministic trend. His main point is that the existence of exogenous shock which has a permanent effect will lead to a non-rejection of the unit root hypothesis even though it is true.

Perron (1989) proposed a unit root test allowing for a structural break with three alternative models: crash model (i.e., shift in the intercept), changing growth model (i.e., change in the slope) and the change both in the intercept and the slope. Several studies have found that the conventional unit root tests fail to reject the unit root hypothesis for the series that are actually trend stationary with a structural break. On the other hand, the Perron (1989) test has been generally criticized for treating the time of break as exogenous (i.e., the time of break is known a priori). (Christiano, 1992; and Altinay and Karagol, 2004).

Zivot and Andrews (1992) further developed the Perron unit root tests that consider the breakpoint (τb) as endogenous. To test for a unit root against the alternative of trend stationarity process with a structural break both in slope and intercept, the following regressions are used:

p

$$Y_t = \mu + \theta DU_t(\tau b) + \beta T + \alpha Y_{t-1} + \sum_{i=1} \phi_i \Delta Y_{t-i} + u_t \qquad (4)$$

$$Y_t = \mu + \gamma DT_t(\tau b) + \beta T + \alpha Y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + u_t \qquad (5)$$

$$Y_t = \mu + \theta DU_t(\tau b) + \beta T + \gamma DT_t(\tau_b) + \alpha Y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + u_t \qquad (6)$$

Where DU_t and DT_t are dummy variables for a mean shift and a trend shift respectively; $DU_t(\tau b) = 1$ if $t > \tau b$ and 0 otherwise, and $DT_t(\tau b) = t - \tau b$ if $t > \tau b$ and 0 otherwise. In other words, DU_t is a sustaine dummy variable that captures a shift in the intercept, and DT_t represents a shift in the trend occurrin at time τ b. The breakpoint τ b can be found by using the Quandt-Andrews breakpoint test. The optimal lag length *p* is also determined by using the general to specific approach so as to minimize the AIC or SIC. The Zivot and Andrews (1992) unit root test suggests that we reject the null hypothesis of a unit root if computed $t\hat{\alpha}$ is less than the left-tail critical *t* value.

3.2 Cointegration Analysis

Once the order of integration of each variable is established, we then evaluate whether the variables under consideration is cointegrated. According to Engle and Granger (1987), a linear combination of two or more nonstationary series (with the same order of integration) may be stationary. If such a stationary linear combination exists, the series are considered to be cointegrated and long-run equilibrium relationships exist. Thanks to the existence of cointegration, although the series are individually nonstationary, they cannot drift farther away form each other arbitrarily.

Cointegration implies that causality exists between the two variables, but it does not indicate the direction of the causal relationship. The presence of cointegration among the variables rules out the possibility of 'spurious' regression (Belloumi, 2010). There are various approaches to test for cointegration, say, Engle and Granger approach, Johansen approach, ARDL bounds testing approach (by Pesaran *et al*., 2001), and Gregory and Hansen approach.

According to Belloumi (2010), the bivariate approach of Engle and Granger is very restrictive because it can be applied only if there is one cointegrating relation. And the most commonly used method is the Johansen cointegration test based on the autoregressive representation discussed by Johansen (1988) and Johansen and Juselius (1990). This test determines the number of cointegrating equations for any normalization used. It provides two different likelihood ratio tests; one is based on the trace statistic and the other on the maximum eigenvalue.

Esso (2010) states that the cointegration framework of Engle and Granger (1987), and Johansen (1988) has its limitations especially when dealing with economic data containing the structural breaks.

In this case, we tend to reject the hypothesis of cointegration, albeit one with stable cointegratin parameters. The reason is that the residuals from cointegrating regressions capture unaccounted breaks and thus typically exhibit nonstationary behaviour. Therefore, it's necessarily to employ the non-linear techniques for testing cointegration if the economic data has structural breaks. One of the widely used methods is the Gregory and Hansen (1996a,b) threshold cointegration test. And the test equation is expressed as below:

$$Yt = \mu 1 + \mu 2\ DUt(\tau b) + \beta 1T + \beta 2T.\ DUt(\tau b) + \alpha 1Xt + \alpha\ 2Xt\ .DUt(\tau b) + ut \qquad (7)$$

$$Xt = \mu 1 + \mu 2\ DUt(\tau b) + \beta 1T + \beta 2T\ .DUt(\tau b) + \alpha 1Yt + \alpha\ 2Yt\ .DUt(\tau b) + ut \qquad (8)$$

Where $\mu 1$ and $\mu 2$ represent the intercept before the shift and the change in the intercept at the time of the shift; $\beta 1$ and $\beta 2$ are respectively the trend slope before the shift, the change in the trend slope at the time of the shift; $\alpha 1$ is the cointegrating slope coefficient before the regime shift, $\alpha 2$ denotes the change in the cointegrating slope coefficient at the time of the regime shift; Y_t and X_t denote LPCEC*t* and LPCGDP*t*. The standard methods to test the null hypothesis of no cointegration are residual-based. The equations (7) and (8) are estimated by OLS method, and the unit root tests are applied to the regression errors (Gregory and Hansen, 1996a).

3.3 Granger Causality Analysis

Let's denote LPCEC*t* and LPCGDP*t* for the natural logarithms of the corresponding energy consumption and real GDP per capita respectively; and suppose that LPCEC*t* and LPCGDP*t* are both integrated of order 1, the VAR model developed by Granger (1969) can be defined as:

$$\Delta LPCEC_t = \alpha + \sum_{i=1}^{P} \beta_i \Delta LPCEC_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta LPCGDP_{t-j} + u_{1t} \quad (9)$$

$$\Delta LPCGDP_t = \phi + \sum_{i=1}^{P} \theta_i \Delta LPCGDP_{t-i} + \sum_{j=1}^{q} \delta_j \Delta LPCEC_{t-j} + u_{2t} \quad (10)$$

This study use the Akaike's information criterion (AIC) and Schwarz's Bayesian criterion (SBC) to determine the optimal lag length of **Δ**LPCEC*t* and **Δ**LPCGDP*t*. The equations (9) and (10) are first estimated by OLS method, and then we apply the normal *F* Wald test for the joint significance of the coefficients on the lagged terms in the unrestricted models. Specifically, the following null hypotheses are necessarily tested:

(A) H0 : $\sum_{i=1}^{q} \gamma_j = 0$ or economic growth does not Granger cause energy consumption.

(B) H0 : $\sum_{i=1}^{q} \delta_j$ or energy consumption does not Granger cause economic growth.

It is possible to have that (a) energy consumption causes economic growth (reject B, but do not reject A), (b) economic growth causes energy consumption (reject A, but do not reject B), (c) there is a bi-directional feedback between energy consumption and economic growth (reject A and B), and (c) energy consumption and economic growth are independent (do not reject A and B).

According to Mehrara (2007), the most popular method for Granger causality tests, is based on the VECM if variables are cointegrated. The VECM can avoid shortcomings of the VAR based models in distinguishing between a long- and a short-run relationship among the variables. Theoretically, cointegration implies the existence of causality between variables, but it does not indicate the directio of the causal relationship. The VECM is estimated by using the following VAR model:

$$\Delta LPCEC_t = \alpha + \pi_1 ECT_{1,t-1} + \sum_{i=1}^{P} \beta_i \Delta LPCEC_{t-i} + \sum_{j=1}^{q} \gamma_j \Delta LPCGDP_{t-j} + u_{1t} \quad (11)$$

$$\Delta LPCGDP_t = \phi + \pi_2 ECT_{2,t-1} + \sum_{i=1}^{P} \theta_i \Delta LPCGDP_{t-i} + \sum_{j=1}^{q} \delta_j \Delta LPCEC_{t-j} + u_{2t} \quad (12)$$

where the error correction term (ECT*t-1*) is derived from the long-run cointegration relationship and measures the magnitude of the past disequilibrium. The coefficients, π of the ECT*t-1* represent the deviation of the dependent variables from the long-run equilibrium.

Within this VECM model, we can examine whether the relationship between energy consumption and economic growth is weak Granger causality, long-run Granger causality, or strong Granger causality. The weak Granger causality exists if we can find the short-run relationship between energy consumption and economic growth which is based on the normal *F* Wald test for the joint significance of the coefficients on the lagged terms in the unrestricted models (equation (11) and (12)) in the same manner as the null hypotheses (A) and (B). The long-run causality can be tested by looking at the significance of the speed of adjustment, which is the coefficient of the error correction term. This is easily based on the *t* statistic. Specifically, we must test the following null hypotheses:

(C) H0 : $\pi 1 = 0$ or Granger non - causality in the long - run

(D) H0 : $\pi 2 = 0$ or Granger non - causality in the long – run

According to Belloumi (2010), the significance of ‘π’ indicates that the long-run equilibrium relationship is directly driving the dependent variable. If π, say, in equation (11) is zero, then it can be implied that the change in energy consumption does not respond to deviation in the long-run equilibrium for the *t-1* period.

The strong Granger causality between energy consumption and economic growth, which is based on the normal *F* Wald test for joint significance of both the coefficient associated with the ECT*t-1* and the coefficients on the lagged terms in the unrestricted models (equation (11) and (12)) as follows:

(C) $H0 : \pi 1 = \sum_{j=1}^{q} \gamma_j = 0$ or economic growth does not strongly cause energy consumption

(D) $H0 : \pi 2 = \sum_{j=1}^{q} \delta_j = 0$ or energy consumption does not strongly causes economic growth

Above models could include dummy variables in order to take into account the existence of the possible structural breaks during the study sample. In addition, we sometimes include the trend variable if there is the existence of deterministic trend in the relationship between energy consumption and economic growth. These inclusions depend on the actual data property.

4. Empirical Results

4.1 Unit Root Tests

The high coefficient of correlation between two variables (0.86) does not imply cointegration.

According to Granger (1988), the condition for cointegration is that each of the variables should be integrated of the same order (more than zero) or that both series should contain a deterministic trend (Belloumi, 2010). Table 1 report the results of the standard unit root tests (ADF and PP) on the integration properties of the LPCEC and LPCGDP variables for Algeria. Because the actual values of these series does not exhibit trends and constants, so all unit root test regressions does not include constant and trend terms. The number of lags was equal to 1 por LPCEC and 0 for LPCGDP. The choice pf the numner pf jags employed was assigned to the Akaike Information Criterion (AIC).

Table 1. Unit root test results using ADF and PP

Variables	Statistic test ADF	Critical values at 5%	Lag Lenght	Statistic test PP	Critical values at 5%	Conclusion
In Level :						
LPCEC	1.43	-1.95	1	2.50	-1,95	non stationnary series
LPCGDP	1.83	-1.95	0	1.83	-1.95	non stationnary series
In first difference :						
LPCEC	-1.75	-1.61*	1	-3.69	-1.95	I(1)
LPCGDP	-7.45	-1.95	0	-7.45	-1.95	I(1)

Note : I(1): series stationnary in it’s first difference.
*Critical value at 10%

In the level form, a unit root tests are rejected for all the variables. However, the test rejects the null of non-stationarity for all the variables when they are used in its first difference. This shows that all theseries are stationary in the first difference, and integrated of order *I*(1).

4.2 Cointegration Test

Before testing for causality it’s necessary to verify if the series are cointegrated. Applying the Engle and Granger cointegration approach, we obtain the results as shown in Table 2. Residual obtained from OLS regressions between LPCEC and LPCGDP is then tested by using the ADF test.

Table 2. Unit root tests for residual (Engle and Granger) using ADF

Null Hypothesis: RESID01 has a unit root				
Exogenous: None				
Lag Length: 1 (Fixed)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-1.029263	0.2683
Test critical values:	1% level		-2.621185	
	5% level		-1.948886	
	10% level		-1.611932	

The test results indicate that the absolute value of the calculated test statistic for the residual is less than its criticals values. Neither of the series is cointegrated. Therefore, it's hard to have any conclusion about the cointegration between these variables from this simplified test. We then employ the Johansen approach for testing cointegration between LPCEC and LPCGDP.

Table 3. Johansen cointegration estimation results between LPCEC and LPCGDP

Series: LPCEC LCGDP					
Lags interval: 1 to 1 Selected (0.001 level*)					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0
*Critical values based on Mac Kinnon-Haug-Michelis (1999)					

These tests indicate clearly that there is no cointegration between economic growth and energy consumption in Algéria. Therefore the standars Granger test (Granger 1969) is appropriate.

4.3 Granger Causality Tests

Table 4 presents the results of the Granger causality test from economic growth to energy consumption. It is shown that the null hypothesis that energy consumption does not Granger-cause economic growth cannot be rejected. We can conclude that there is a Granger causality running from economic growth to energy consumption. This fact shows that energy consumption is determined by the economic growth in Algeria. In other words, the conservation hypothesis is acceptable.

Table 4. Granger causality tests

Sample: 1965-2008			
Lags: 1			
Null Hypothesis:	obs	F-Statistic	Probability
D(LPCGDP) does not Granger Cause D(LCE)	42	4.63428	0.03758
D(LPCEC) does not Granger Cause D(LPCGDP)		0.52321	0.47379

5. Conclusion

This article investigates the causal relationship between per capita energy consumption and per capita GDP for Algéria during the 1965-2008 period. In doing so, various cointegration testing approaches are employed before testing Granger causality. The results suggest the existence of uni-directional causality running from per capita GDP to per capita energy consumption. The research results strongly support the neoclassical view that energy consumption is not a limiting factor for the Algeria's economic growth. This in turn implies that the rise in energy prices can be a good opportunity for the economy to promote substitution and technological innovation.

From a policy perspective, the results in this study are consistent with the conservation hypothesis. Since a high level of economic growth leads to a high level of energy demand, but not vice versa, the government can pursue the conservation energy policies that aim at curtailing energy use for environmental friendly development purposes. We should gradually establish a competitive energy market in order to allocate these resources into the most productive uses in the economy.

References

Akarca, A.T., Long, T.V. (1980). On the relationship between energy and GNP: A reexamination. *Journal of Energy Development*, 5, 326–331.

Antille, G. **(**1984). Utilisation des tableaux entrées-sorties pour l'analyse des interdépendances entre économie et énergie. *Revue Suisse d'Economie Politique et de Statistique*, 120(3), 261-279.

Altinay, G., Karagol, E. (2004). Structural break, unit root, and the causality between energy consumption and GDP in Turkey. *Energy Economics*, 26, 985–994.

Aqeel, A., Butt, M.S. (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia Pacific Development Journal*, 8, 101–110.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. *Energy Economics*, 22, 615–625.

Asteriou, D., Stephen G.H. (2007). *Applied Econometrics: A Modern Approach Using Eviews and Microfit*, Revised Edition, Palgrave MacMillan.

Bartleet, M., Gounder, R. (2010). Energy consumption and economic growth in New Zealand: Results of trivariate and multivariate models. *Energy Policy*, 38, 3508–3517.

Belloumi, M. (2009). Energy consumption and GDP in Tunisia: Cointegration and causality analysis. *Energy Policy*, 37, 2745–2753.

Chen, S.T., Kuo, H.I., Chen, C.C. (2007). The relationship between GDP and electricity consumption in 10 Asian Countries. *Energy Policy*, 35, 2611–2621.

Cheng, B. (1995). An investigation of cointegration and causality between energy consumption and economic growth. *Journal of Energy Development*, 21, 73–84.

Cheng, B.S., Lai, T.W. (1997). An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. *Energy Economics*, 19, 435–444.

Chiou-Wei, S.Z., Chen, Ching-Fu, Zhu, Z. (2008). Economic growth and energy consumption revisited: Evidence from linear and nonlinear Granger causality. *Energy Economics*, 30, 3063–3076.

Chontanawat, J., Hunt, L.C., Pierse, R., 2008. Does energy consumption cause economic growth? Evidence from a systematic study of over 100 countries. *Journal of Policy Modeling*, 30, 209–220.

Christiano, L.J. (1992). Searching for breaks in GNP. *Journal of Business and Economic Statistics*, 10, 237–250.

Cleveland, C.J., Kaufmann, R.K., Stern, D.I. (2000). Aggregation and the role of energy in the economy. *Ecological Economics*, 32, 301–317.

Engle, R.F., Granger, C.W.J. (1987). Cointegration and error correction: representation, estimation and testing. *Econometrica*, 55, 251–276.

Erol, U., Yu, E.S.H. (1987). On the causal relationship between energy and income for industrializing countries. *Journal of Energy and Development*, 13, 113–122.

Farhani, S., Ben Rejeb, J. (2012). Energy Consumption, Economic Growth and CO_2 Emissions: Evidence from Panel Data for MENA Region, International Journal of Energy Economics and Policy, 2(2), 71-81.

Esso, L.J. (2010). Threshold cointegration and causality relationship between energy use and growth in seven African countries. *Energy Economics*, 30, 2391–2400.

Glasure, Y.U., Lee, A. (1997). Cointegration, error correction and the relationship between GDP and energy: The case of South Korea and Singapore. *Resource and Energy Economics*, 20, 17–25.

Granger, C.W.J. (1969). Investigating causal relation by econometric and cross-sectional method. *Econometrica*, 37, 424–438.

Gregory, A.W., Hansen, B.E. (1996a). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics*, 70, 99–126.

Gregory, A.W., Hansen, B.E. (1996b). Tests for cointegration in models with regime and trend shifts. *Oxford Bulletin of Economics and Statistics,* 58, 555–560.

Hwang, D., Gum, B. (1991). The causal relationship between energy and GNP: The case of Taiwan. Journal of Energy Development, 16, 219–226.

Johansen, S., 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231–254.

Johansen, S., Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics,* 52, 169–209.

Kraft, J., Kraft, A. (1978). On the relationship between energy and GNP. *Journal of Energy Development,* 3, 401–403.

Lau, E., Chye, Xiao-Hui, Choong, Chee-Keong. (2011), *Energy-Growth Causality: Asian Countries Revisited*. International Journal of Energy Economics and Policy, 1(4), 140-149.

Masih, A., Masih, R. (1996). Energy consumption and real income temporal causality, results for a multi-country study based on cointegration and error correction techniques. *Energy Economics,* 18, 165–183.

Masih, A.M.M., Masih, R. (1997). On temporal causal relationship between energy consumption, real income and prices; some new evidence from Asian energy dependent NICs based on a multivariate cointegration/vector error correction approach. *Journal of Policy Modeling,* 19, 417– 440.

Ozturk, I., Acaravci, A. (2010), The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary and Romania: Evidence from ADRL bound testing approach. Applied Energy, 87, 1938-1943.

Ozturk, I., Aslan, A., Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. *Energy Policy,* 38, 4422-4428.

Ozturk, I. (2010). A literature survey on energy–growth nexus. Energy Policy, 38, 340–349.

Paul, S., Bhattacharya, R.N. (2004). Causality between energy consumption and economic growth in India: A note on conflicting results. *Energy Economics,* 26, 977–983.

Perron, P. (1989). The great crash, the oil price shock and the unit root hypothesis. *Econometrica,* 57, 1361–1401.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds testing approaches to the analysis of levels relationships. *Journal of Applied Econometrics,* 16, 289–326.

Solow, R.M. (1974). The economics of resources or the resources of economics. *American Economic Review,* 64, 1-14.

Solow, R.M. (1997). Reply: Georgescu-Roegen versus Solow/Stiglitz. *Ecological Economics,* 22, 267-268.

Soytas, U., Sari, R. (2003). Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets. *Energy Economics,* 25, 33–37.

Stern, D.I., 1993. Energy and economic growth in the USA: A multivariate approach. *Energy Economics*, 15, 137–150.

Yu, E.S.H., Choi, J.Y. (1985). The causal relationship between energy and GNP: An international comparison. *Journal of Energy and Development,* 10, 249–272.

Yu, E.S.H., Hwang, B.K. (1984). The relationship between energy and GNP, further results. *Energy Economics,* 6, 186–190.

Zivot, E., Andrews, D.W.K. (1992). Further evidence on the great crash, the oil price shock, and the unit root hypothesis. *Journal of Business and Economic Statistics,* 10, 251–270.