ENERGY AND ECONOMIC GROWTH: THE ALGERIEN CASE

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Abstract

This study analyses the causal relationship between the per capita energy consumption and the per capita GDP in Algeria by using annual data from 1980 to 2007. We include capital and labor as additional variables to the energy-growth nexus. We use Granger causality test and the variance decomposition analysis. The results give the evidence of causality running from energy consumption to economic growth. The variance decomposition analysis reveals that energy was no more than a minor contributing factor to output growth and certainly not the most important one when compared to capital and labor. Capital is the most important factors in output growth in Algeria.

Keywords: Capital, Economic growth, Energy consumption, Labor, Causality.

I. Introduction

The causal relationship between economic growth and energy in a country represents a commonly studied topic in energy economics literature. Even though it is very well known that there is a strong correlation between growth and energy use, the issue of “causality” – i.e. That is, whether economic growth leads to energy consumption or that energy consumption is the engine of economic growth.- remains still to be answered (Sari et al. (2001); Konya (2004), (2004); Masih and Masih (1996)).

Recently, this question has faced a renewed interest given the increasing debate about the world climate changes as a consequence of greenhouse gases emissions. The direction of causality, in fact, can assist the policy makers to take the most suitable decisions in climatic matters: for instance, evidence of unidirectional causality running from income to energy consumption could suppose the full compatibility between energy conservation policies and economic growth policies since the firsts can be pursued without limiting the seconds. On the opposite the finding of unidirectional causality running from energy consumption to income may assume a particular significance with regard to the current debate about whether developing countries should be allowed to pollute more than the industrialized world, arguing that energy consumption could represent a stimulus for economic growth (Guttormsen (2004)).

Empirically it has been tried to find the direction of causality between energy consumption and economic activities for the developing as well as for the developed countries employing the Granger or Sims techniques. However, results are mixed. Like other developing countries Algeria is also an energy intensive growing economy, and has experienced a significant economic upturn in recent years. In 2006, Algeria’s real gross domestic product (GDP) growth rate was 4.0 percent. Oil and natural gas exports, which made up 98 percent of Algerian exports (by value) in 2006, are the main driver of Algerian economic growth. With continuing investments being made in Algerian oil and gas development, both sectors have potential for increasing production capacity over the next few years.

The investigation about African countries is almost wholly based on the bivariate causality model with energy consumption used as the only factor input. It is against this background that this paper tries to fill the gap by examining the inter-temporal causal relationship between economic growth and energy in a production function framework by including capital and labor as intermitting variables. In doing so, the purpose of this paper is to add to the debate by examining the causal relationship between energy and economic growth for Algeria by extending the debate in three methodological approaches. First, we include capital and labor as additional variables to the energy-growth nexus as only energy might not be strong enough to urge economic growth. Second, we use a version of the Granger causality test where the procedure requires knowledge of the stationarity and cointegrating properties of the system. Third, as previous empirical evidence for Algeria did not attempt to evaluate the strength of their causality findings beyond the sample period, we use variance decomposition analysis due to Pesaran and Shin (1998), which, unlike the conventional method, is invariant to the order of the variables in which they enter the VAR. By doing so, we can assess how each variable responds to the innovation of other variables in the system and also evaluate how important is the causal impact of energy on economic growth relative to capital and labor (Shan (2005)).

The results of our multivariate Granger causality analysis give the evidence of causality running from energy consumption to economic growth. The variance decomposition analysis reveals that energy was no more than a minor contributing factor to output growth and certainly not the most important one when compared to capital and labor. Capital is the most important factors in output growth in Algeria. The finding of the variance decomposition analysis appears to support the vision that energy is neutral to aggregate economic activity.

The reminder of this study is organized as follows. The second section summarizes the past studies on this topic. Section 3 illustrates the distinctive characteristics of the Algerian energy sector. Section 4 reports the methodology. The fifth reports the results and discussion. Finally, section 6 ends with some concluding remarks.

II. Literature review

Over the precedent few years the relationship between economic growth and energy has been widely researched. Since the pioneering study of Kraft and Kraft (1978), the great amount of researches in this matter find evidence of unidirectional, bidirectional, or no causality according to the country studied. Furthermore, in some countries, different results occur for different time periods, leading to no definite conclusion.

With regard to several empirical contributions, evidence of bidirectional relationship is established in the studies of Jumbe (2004) and Ghali and El-Sakka (2004) which examine Malawi and Canada respectively. On the other hand, the works of Morimoto and Hope (2004) and Wolde- Rufael (2004) in Sri-Lanka and Shangai demonstrate the existence of unidirectional causality from energy consumption to economic growth. The findings of Soytas and Sary (2003) are once more varied: their empirical study of G7 countries and some emerging markets over several time periods suggest the presence of bidirectional causality in Argentina, unidirectional causality from GDP to energy consumption in Italy and Korea, and unidirectional causality from energy consumption to gross domestic product (GDP) in Turkey, France, West Germany and Japan. In the end, the work of Oh and Lee (2004) in Korea reports evidence of a long-run bidirectional causal relationship and a short-run unidirectional causality from energy to GDP.

In an analysis of over more than hundred countries, Chontanawat et al. (2008) find that the causal relationship between energy and economic growth is more marked in developed than in developing countries. Sari and Soytas (2007) in a study of six emerging countries find energy to be a key factor of production. In a bivariate relationship between economic growth and energy in African countries, Wolde-Rufael (2005) also discovers conflicting results with little support for the hypothesis that energy causes economic growth. Similarly, using a multivariate causality test, Akinlo (2008) found also contradictory evidence for eleven African countries. Linear and nonlinear Granger causality carried out for eight newly industrialized Asian and USA by Chiou-Wei et al. (2008) reports also inconsistent results.

Mahadeven and Asafu-Adjaye (2007) find bidirectional causality for a number of countries while for others they report unidirectional causality running from energy consumption to economic growth. Likewise, Huang et al. (2008) find no causality between economic growth and energy consumption in low-income groups while in middle-income and high-income countries they found that economic growth leads energy consumption. Lee (2005) in a study for a group of 18 emerging countries discovers causality running from energy to economic growth but not vice versa. Also, in an analysis of sixteen Asian countries, Lee and Chiang (2008) found a long-run causality running from energy consumption to economic growth. Further, for a group of 22 OECD countries Lee et al. (2008) report a bidirectional among energy consumption, the capital stock and economic growth. In a panel of G7 countries, Narayan and Smyth (2008) found that capital formation, energy consumption Granger cause real GDP positively in the long run. In contrast, Al- Iriani (2006) for a group of six Gulf Cooperation countries found a unidirectional causality running from economic growth to energy consumption. Wolde-Rufael (2008) re-examine the causal relationship between energy consumption and economic growth for seventeen African countries in a multivariate framework by including labor and capital as additional variables. The results tend to reject the neutrality hypothesis for the energy–income relationship in fifteen out of the seventeen countries.

With the omission of the clear differences among countries in terms of structural and economic policy characters, the diversity of findings obtained depend upon the adopted variables and, above all, from the methodological approach used to test causality. Initially the causal relationship was checked by using the standard Granger (1969) test and the Sims' (1972) approach. These two methodologies suppose that data series are stationary. As pointed out by Granger (1986), (1988), these tests do not permit to find any long-run information between the variables, being able to capture only the short-run relationships. For this reason, the empirical findings of causal linkages based on these tests are often inconsistent. Later, researchers begin to employ a cointégration approach which is now considered as the most appropriate to investigate for causality since overcomes the problems depicted before.

III. Energy sector in Algeria

Algeria has oil and gas infrastructures of scale, reliable, and accessible. It accumulated an incomparable experience in the development and the exploitation of the gas fields, in the exercise of the trades of the transport by pipeline, in the liquefaction of natural gas where it occupies a position of leader, in the maritime transport and the proven knowledge of the liquefied natural gas world market. Being an oil and gas producer, Algeria is closely following the energy market development, at a global and European levels; its development and energy strategies are build upon partnership and cooperation opportunities with producers, industrial operators, dealers and consumers.

Subsequent years of political unrest and civil war, Algeria now is experiencing an important economic upturn, in large fraction supported by strong oil and natural gas export revenues. The sharp increase in oil export revenues that Algeria has enjoyed during the past few years has caused the country's foreign reserves to rebound sharply. In late 2007, foreign reserves totaled over $110 billion, compared to $78 billion and $56 billion at the end of 2006 and 2005, respectively.

According to the *Oil and Gas Journal* (OGJ), Algeria contained an estimated 12.2 billion barrels of proven oil reserves as of January 2007. With recent oil discoveries and plans for more exploration drilling, proven oil reserve estimates could increase in coming years. Algeria should also see an increase in crude oil exports over the next few years, due to the substitution of natural gas for oil in domestic energy consumption. Analysts consider Algeria underexplored, even though the country has produced oil since 1956, and Algeria's National Council of Energy believes that the country still contains vast hydrocarbon potential. Over the last few years, there have been significant new oil and gas discoveries, largely by foreign companies: Algeria's oil sector, unlike the majority of producers in the Organization of Petroleum Exporting Countries (OPEC), has been open to foreign investors for more than a decade. Algeria hopes to increase its crude oil production capacity significantly over the next few years by attracting more foreign investment.

Algeria's average crude oil production during 2006 was 1.81 million barrels per day (bbl/d). Together with 445,000 bbl/d of lease condensate and 309,930 bbl/d of natural gas plant liquids, Algeria averaged about 2.08 million bbl/d of total oil production during 2006. Algeria's crude oil production is running well above its OPEC quota of 894,000 bbl/d (as of January 1, 2006), though the OPEC quota only applies to crude oil production. In coming years, it is likely that Algeria's oil production capacity will rise as the country plans to increase investments in exploration and development efforts. Algeria's production goal is 2.0 million bbl/d by 2010.

With domestic oil consumption of 259,000 bbl/d in 2006, Algeria had estimated net oil exports (including all liquids) of 1.84 million bbl/d. Approximately 90 percent of Algeria's crude oil exports go to Western Europe, with Italy as the main recipient followed by Germany and France. Algeria’s Saharan Blend oil, 45° API with negligible sulfur content, is among the highest quality in the world. European countries have relied upon Algerian oil to help meet increasingly stringent EU regulations on sulfur content of gasoline and diesel fuel.

Commercial production of natural gas in Algeria began in 1961. The country produced 3.079 Tcf of natural gas in 2006, the fifth-largest in the world and the largest among OPEC member countries. In 1997, Algeria's natural gas production exceeded the country's crude oil production for the first time. Algeria consumed 0.904 Tcf of natural gas in 2006, some 29 percent of its production. The Algerian government has encouraged the domestic use of natural gas, which represented over 70 percent of the country's total energy consumption in 2006. The remaining natural gas is exported, with the majority going to Europe and the United States.

IV. Data and methodology

Until a moment ago, energy as a separate factor input in the production procedure has been deserted as its role is considered to be marginal because the cost of energy accounts for only a very small proportion GDP compared to the cost of employment (Ghali and El-Sakka (2004); Lee et al. (2008)). Recently numerous studies have attempted to highlight the importance of energy in the production process and they have tried to incorporate energy as an addition factor of production in addition to labor and capital (Beaudreau (2005); Ghali and El-Sakka (2004); Lee and Chiang (2008); Lee et al. (2008); Narayan and Smyth (2008); Oh and Lee (2004); Sari and Soytas (2007); Soytas and Sari (2006); Stern (2000); Yuan et al. (2008); and Wolde-Rufael (2008)). In this work, following the aforesaid authors we examine the causal relationship between energy consumption and economic growth in a conventional neo-classical one-sector aggregate production model where capital, labor and energy are treated as separate factors of production:

$$LGDP = \alpha_0 + \beta_1 LCAP + \beta_2 LLAB + \beta_3 LENE + \varepsilon_t \quad (1)$$

In this log linear form, GDP is aggregate output or real gross domestic production, CAP is capital stock, LAB is level of employment, and ENE is total energy consumption.

The potential benefits to economic growth may depend on the degree to which energy, labor and capital act as complements. By including capital and labor as supplementary variables, we not only try to highlight the significance of these two factors of production for economic development but we can also test the hypothesis that capital and labor support economic growth or vice versa. Moreover, we incorporate these two variables because omission of a pertinent variable(s) makes not only the forecasts biased as well as conflicting but also no-causality in a bivariate system can result from ignored variables (Lütkepohl (1982)). Thus the previous bivariate causality tests between energy consumption and economic growth may be invalid due to the exclusion of important variables affecting both energy consumption and economic growth. It is possible that the introduction of capital and labor in the causality framework may not only modify the direction of causality but also the level of the estimates (Loizides and Vamvoukas (2005); Odhiambo (2008)). Further, since a four VAR case integrates more information than the bivariate case, the causal conclusion drawn can be more consistent (Loizides and Vamvoukas (2005)).

To test the nature of association between the four variables while avoiding any spurious correlation, the empirical investigation in this paper follows the four steps. We begin by testing for non-stationarity in the four variables of LGDP, LCAP, LLAB and LENE. Prompted by the existence of unit roots in the time series, we test for long-run cointegrating relation between variables at the second step. Granted the long-run relationship, we explore the causal link between the variables by testing for Granger causality at the third step. At the end, we investigate the variance decomposition.

A) Unit root test

Since many macroeconomic series are non stationary (Nelson and Plosser (1982)), unit root tests are useful to determine the order of integration of the variables and, therefore, to provide the time-series properties of data. In order to implement a rigorous test to verify the presence of a unit root in the series, an Augmented Dickey-Fuller (ADF) test is employed. This test represents a wider version of the standard Dickey-Fuller (DF) test (1979), (1981).

Given a simple AR(p) process:

$$\Delta y_t = \alpha + \beta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

Where Δ is the first difference operator, y_t is a time series, α, β and φ are parameter to be estimated and ε_t is a white noise. The tests are based on the null hypothesis (H_0) is: y_t is not I(0), If the calculated ADF statistics are less than their critical values from Fuller's table, then the null hypothesis (H_0) is rejected and the series are stationary or integrated or order one i.e. I(1).

B) Cointegration test

Generally speaking, two or more variables are said to be cointegrated if they share a common trend. In other words, the series are linked by some long-run equilibrium relationship from which they can deviate in the short-run but they must return to in the long-run, i.e. they exhibit the same stochastic trend (Stock and Watson (1988)). Cointegration can be considered as an exception to the general rule which establishes that, if two series are both I(1), then any linear combination of them will yield a series which is also I(1). The exception is when a linear combination of two or more series is integrated of a lower order: in this case, in fact, the common stochastic trend is cancelled out, leading to something that is not spurious but that has some significance in economic terms.

The existence of a cointegration relationship between the series y_t and x_t is verified implementing a unit root ADF test on the residuals from the following two long-run regressions between the levels variables, estimated through the OLS method:

$$y_t = a_0 + a_1 x_t + \mu_t \tag{3}$$

$$x_t = b_0 + b_1 y_t + \eta_t \tag{4}$$

C) Causality test

Following Granger (1969), the concept of "causality" assumes a different meaning with respect to the more common use of the term. The statement " y_t Granger causes x_t" (or vice versa), in fact, does not imply that y_t (x_t) is the effect or the result of x_t (y_t), but represents how much of the current y_t (x_t) can be explained by the past values of y_t (x_t) and whether adding lagged values of x_t (y_t) can improve the explanation. For this reason, the causality relationship can be evaluated estimating the following two regressions:

$$\Delta y_t = \alpha_1 + \sum_{i=1}^{m} \beta_{1,i} \Delta y_{t-1} + \sum_{i=1}^{m} \gamma_{1,i} \Delta x_{t-i} + \varepsilon_{1,t} \tag{5}$$

$$\Delta x_t = \alpha_2 + \sum_{i=1}^{m} \beta_{2,i} \Delta x_{t-1} + \sum_{i=1}^{m} \gamma_{2,i} \Delta y_{t-i} + \varepsilon_{2,t} \tag{6}$$

Where m represents the lag length and should be set equal to the longest time over which one series could reasonable help to predict the other. Following this approach, the null hypothesis that x_t does not Granger cause y_t in regression (5) and that y_t does not Granger cause x_t in regression (6) can be tested through the implementation of a simple F-test for the joint significance of, respectively, the parameters $\gamma_{1,i}$ and $\gamma_{2,i}$.

D) Forecast error variance decomposition

As we know, a vector autoregression (VAR) can be written as a vector moving average (VMA). So, the following equation:

$$X_t = A_0 + A_1 X_{t-1} + \varepsilon_t \tag{7}$$

Can be written as:

$$X = \mu + \sum_{j=0}^{\infty} A1^{j} \varepsilon_{t-j} \tag{8}$$

Where $\mu = (I + A_1 + A_2 + ...)A_0$ is the conditional mean of X_t.

The fact that (8) is the VMA representation of (7) in that variables (X_t) are expressed in terms of the current and past values of the various types of shocks (ε_{it}). The VMA representation of (7) is an essential feature of Sims (1980) methodology in that it allows a tracing out of the time path of the various shocks on the variables contained in the VAR system. In order to represent the behavior of the (X_t) series in response to the various shocks (e_{it}), we choose to use 'forecast error variance decomposition' to show the proportion of the movements in a sequence (say variable 1) due to its own shocks (ε_t) versus shocks from other variables (ε_{2t}–ε_{1t}). If we use (8) to conditionally forecast X_{t+n} the n-period forecast error is:

$$X_{t+n} - E_t X_{t+n} = \sum_{j=0}^{n-1} A1^{j} \varepsilon_{t+n-j} \tag{9}$$

Where: $Var(\varepsilon_t) = \sigma^2$. Thus the ratio of:

$$W_1(i) = \sigma_i^2 \sum_{j=1}^{n-1} a_{1,i}(j)^2 / \sigma_1(n)^2 \tag{10}$$

represents the proportion of movements in variable 1, x_{1t}, due to shocks from variable i, ε_{it}. If ε_{2t}–ε_{11t} shocks explain none of the forecast error variance of x_{1t} at all forecast horizons, we can say that the x_{1t}, sequence is 'fully exogenous'. In such a circumstance, the x_{1t} sequence would evolve independently of the ε_{2t}–ε_{11t}, and x_{2t}–x_{11t}, sequence. At the other extreme, ε_{2t}-ε_{11t} shocks could explain all the forecast error variance in the x_{1t} sequence at all forecast horizons, so that x_{1t} sequence would be 'fully endogenous'. The ratio $W_i(i)$, for i=1, 2,…11 that is the proportion of movements in variable i, which can be explained by its own shock ait, can be used to represent the 'degree of exogeneity' of variable *i* in response to shock.

Our study uses annual data for the period 1980–2007. All variables used are in natural logarithms. GDP ($LGDP_t$) and real gross capital formation ($LCAP_t$) are in constant US dollars (2000=100). Employment ($LLAB_t$) is total labor force. The choice of the starting period was constrained by the availability of data on labor force. All data are extracted from the World Bank, World Development Indicators 2007. Some descriptive statistics are presented in Table 1.

Table 1. Some basic statistics

	Mean	***Min***	***Max***	***Std. Dev.***
Real GDP per capita	1871.333	1631.863	2156.777	144.6859
Energy use per capita	928.2500	647.0000	1066.000	95.99368
Gross capital formation per capita	665.0713	426.0374	984.8084	188.9877
Share of labor force in total population	32.04721	25.51058	42.37556	5.563898

Source: Author's calculation from WDI 2007

Algeria is heavily dependent on oil revenues and enjoying implicit generous subsidies for energy. As most of the oil exporting countries, Algeria has recorded low annual output growth per. Although, economic performance has been influenced by oil revenue volatility and ''stop-go'' policies, Algeria has done far less well than resource-poor countries over the past few decades, particularly when considering the massive revenue gains to the oil exporting countries since 1973. Many studies support the ''paradox of plenty'' or ''natural resource curse'' (recent examples include Auty (2001); Gylfason, (2000) and (2001)). To avoid lower rates of growth or stagnation in the non-oil sectors, these countries make high demands on energy resources with cheap domestic energy particularly in times of high world energy prices.

In Algeria, energy use growth has been far more than economic growth (on a per capita basis). The gap between GDP and energy use growth is highest, and a similar pattern of results is obtained using the energy intensity (defined as the amount of energy consumption per GDP). Reasons for this include the low price that has been paid historically for fuels and the importance of the petrochemical sector in many of the oil exporting countries (OPEC, 2004).

The policy makers in these countries consider energy as a limiting factor to economic growth, worrying that phasing out energy subsidies may adversely affect GDP growth or cause a fall in the GDP. Given implausibly high oil consumption in oil exporting countries and the recent phenomenal growth in awareness of and concern for global warming, an examination of the energy–income relationship has important implications for energy policy in these countries. It is important to add that most of the studies referred to above have dealt with countries relying on imports for their energy needs and it may be argued that the results are not applicable to net exporters of fuel.

V. Results and discussion

The results of our estimations are presented step by step and are as follows:

A) Unit root test

In the present study an ADF test was performed to ln(GDP), ln(ENE), ln(LAB) and ln(CAP) series. In all cases, a constant and a linear trend were included since this represents the most general specification. The max number of lags was set equal to 3. The choice of the number of lags actually employed was assigned to the Akaike Information Criterion (AIC). Table 2 reports the results obtained.

Table 2. Unit root test

	Level	*First difference*	*Second difference*
Real GDP per capita	-1.214084	-3.211281*	-
Energy use per capita	-1.299791	-2.299444	-3.969234*
Gross capital formation per capita	-0.142213	-3.087703*	-
Share of labor force in total population	-2.453604	-4.849624	-

* indicates significance at 1% level

In the level form, ADF class of unit root test is rejected for all the variables. However, the test rejects the null hypothesis of non-stationarity for all the variables when they are used in the first difference except for energy. This shows that, except for energy which is I(2), all the series are stationary in the first difference, and integrated of order I(1).

B) Cointegration test

Before testing for causality it's necessary to verify if the series are cointegrated. As before, in all cases the max number of lags to be used was set equal to 3 and the choice of the number of lags actually employed was assigned to the Akaike's final prediction error criterion. Table 3 reports the results obtained from the cointegration tests.

Table 3. Cointegration test

	ADF
Capital→ GDP	-1.296745
GDP → Capital	-2.231779
Labor→ GDP	-1.216303
GDP → Labor	-1.749358
Capital →Labor	-0.571552
Labor→ Capital	-0.184848

The variables which have been tested for the order of integration and found to have the same order are used to estimate cointegration regression. Table 3 reports the results of the ADF test applied to the residuals of the cointégration equations. The absolute values of the calculated test statistics for all the residuals are less than its critical value at the 5 per cent level. Neither of the series is cointegrated. Therefore the standard Granger test (Granger (1969) is appropriate.

C) Granger causality test

Results of the Granger causality test are presented in Table 4. The most striking result of our empirical evidence is that the introduction of both gross capital formation and labor has altered the direction of causality in Algeria that was previously investigated by Wolde-Rufael (2005).

Table 4. Granger causality test

	F statistics	*ρ-value*
Energy** doesn't cause **GDP	0.19532	0.82405
GDP** doesn't cause **Energy	2.69684	0.09069***
Capital** doesn't cause **GDP	4.77704	0.01950**
GDP** doesn't cause **Capital	1.06294	0.36331
Labor** doesn't cause **GDP	2.45699	0.10995
GDP** doesn't cause **Labor	0.91144	0.41727
Capital** doesn't cause **Energy	2.94330	0.07468***
Energy** doesn't cause **Capital	0.04513	0.95597

Energy** doesn't cause **Labor	1.21404	0.31701
Labor** doesn't cause **Energy	8.05255	0.00254*
Capital** doesn't cause **Labor	2.75658	0.08649***
Labor** doesn't cause **Capital	3.83799	0.03796**

*, ** and *** indicate significance at 1%, 5% and 10% level respectively.

For Algeria causality was reversed from economic growth to energy consumption, comparing to the one found in Wold-Rufael (2000), to the opposite causality running from energy consumption to economic growth contrary to the no causality found by Chontanawat et al. (2008). This means that the inclusion of past values of LENE in the equation of LGDP provides a better explanation to the current LGDP. We also record a unidirectional causality running from energy consumption to capital and a bi-directional one between capital and labor force.

Even though this analysis is required to loosen the reasons behind the reversal of the direction of causality, it is possible to propose few plausible causes that may have aided this reversal. At first, energy alone might not have been powerful enough to encourage economic growth because the possible gains to economic growth may depend on the degree to which energy, capital and labor act as complements in the growth process. Algeria is still labor plentiful and growth of output may still mainly depend on labor being augmented by energy and capital. Indeed energy is no more than a contributing factor to output growth and certainly not the most significant one when compared to capital and labor. Secondly, the insertion of capital and labor might have also aided to minimize the possible bias that results from the oversight of a vital variable affecting both energy consumption and economic growth.

Another possible justification is that economic liberalization which has not helped Algeria to achieve relatively higher growth rates. So, the evidence of causality running from energy consumption to economic growth reflects that economic growth performance is relatively low. Also, the fact that GDP doesn't cause the energy consumption can be explained by the fact that Algeria has not rushed into privatization of their power sector (ECA (2008). In this country, power sector has performed relatively well particularly in terms of increased access to electricity among population, including the poor. The direction of causality running from energy consumption to economic growth can be due to the abundance of energy resources.

D) Variance decomposition analysis

The Granger-causality tests presented above show only the presence of causality between economic growth and the other three factors of production. They do not give any information on how important is the causal impact that energy has on output growth (Ghali and El-Sakka (2004); Soytas and Sari (2006); Sari and Soytas (2007)). To assess how each variable responds to innovations in other variables, we have applied the generalized forecast error variance decomposition analysis due to Pesaran and Shin (1998). This method can permit inferences to be drawn regarding the proportion of the movement in a particular time-series due to its own earlier "shocks" vis-à-vis "shocks" occurring from other variables in the VAR where it is probable to recognize which variables are strongly affected and those that are not. Results of the generalized variance decomposition analysis are presented in Table 5.

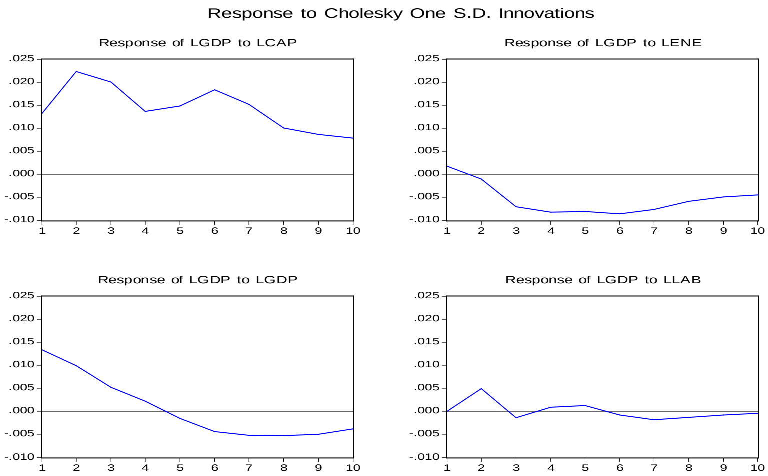
Table 5. Generalized forecast error variance decomposition results for GDP

Horizon	*GDP*	*Energy*	*Capital*	*Labor*
1	50.17720	0.911707	48.91109	0.000000
3	20.93792	3.661413	73.63072	1.769947
5	15.57665	9.232923	73.78345	1.406981
7	13.02416	11.48472	74.32647	1.164654
10	13.55155	12.57329	72.77326	1.101899

As we are more concerned by the role of energy consumption to economic growth as compared to other two inputs of labor and capital, we only decompose the forecast-error variance of the output variable ($LGDP_t$) in response to a one standard deviation innovation in capital ($LCAP_t$), labor ($LLAB_t$) and energy ($LENE_t$). The most interesting result of our analysis is that while causality between energy consumption and economic growth was detected, energy, relative to capital and labor, is not the single most significant factor in explaining innovation to economic growth. In Algeria, energy was the second most important factor when compared to capital and labor.

While energy appears to be an important contributing factor to output growth in many developed and some developing Asian countries (Soytas and Sari, 2006; Sari and Soytas, 2007), our variance decomposition analysis shows that in Algeria, energy is no more than a contributing factor to output growth and certainly not the most important one when compared with capital. Capital is the most important factors in output growth (Table 5). After 5-year horizon, the shocks to GDP due to shocks of energy were very negligible.

The relatively low level contribution of energy to output growth for Algeria may be an indication that the causal relationship between energy consumption and economic growth is relatively weak when compared to either capital. The low level of economic development that characterizes this country reflects and reinforces the limited energy development and consumption (Howells et al., 2008; Prasad, 2008). The current energy infrastructure is insufficient to promote sustainable economic development (ECA, 2004).



The causality results detected in this study have major implications for energy policy. For countries such as Algeria where we establish evidence of a uni-directional causality running from energy consumption to economic growth, reducing energy consumption could lead to a fall in economic growth. Thus, any energy conservation measures undertaken should give significant interest to the adverse effects on economic growth. This country must find ways of increasing the quality and quantity of energy services while simultaneously addressing the environmental impacts associated with energy use (IEA, (2005)).

VI. Conclusion

In this study we analyze the causal relationship between economic growth and energy consumption in Algeria using a multivariate framework by including labor and capital in the causality analysis. The results of our multivariate Granger causality analysis give the evidence of causality running from energy consumption to economic growth. The variance decomposition analysis reveals that energy was no more than a minor contributing factor to output growth and certainly not the most important one when compared to capital and labor. Capital is the most important factors in output growth in Algeria. The finding of the variance decomposition analysis appears to support the vision that energy is neutral to aggregate economic activity.

When we found evidence of a unidirectional causality running from energy consumption to economic growth, reducing energy consumption could guide to a drop in economic growth. As a consequence, when any energy conservation measures are undertaken, considerable care should be taken not to adversely affect economic growth.

Irrespective of the strength of the causal relationship between energy consumption and economic growth, the energy challenge facing Algeria is daunting. Since in Algeria the current energy infrastructure is simply insufficient to promote sustainable economic development, this country can stimulate economic growth by investing more on energy and by reducing energy inefficacy in the supply and use of energy. Unfortunately, in Algeria, it is not energy lack that is the basic problem but the lack of "…institutions, rules, financing mechanisms, and regulations needed to make markets work in support of energy for sustainable development" (UNDP, 2004). Until these elementary limitations that are restraining the development of an efficient and accessible energy sector are fully solved, energy supply will still persist to be a major obstacle for the economic and social development Algeria.

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