# A Structural VAR analysis of Energy Consumption, Economic Growth and CO2 Emissions: Evidence from Algeria.

# تحليل هيكلي باستعمال نموذج VARلاستهلاك الطاقة، النمو الاقتصادي وانبعاثات ثاني أكسيد الكربون. دراسة حالة الجزائر.

# Analyse par le modèle SVAR de la Consommation d'énergie, de la croissance économique et des émissions de CO2. Le cas de l'Algérie.

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**Abstract:**
This analytical review explores the relationships between energy consumption, economic growth and CO2 emissions in Algeria for the period 1970-2017, we use a structural VAR approach based on Blanchard and Quah (1989), Results of unit root tests show that all variables are stationary in first difference form and co-integration analysis analyzed through Johansen-Juseluis (1990), shows that there is no evidence of co-integration among the test variables, The findings of this study reveal that a positive shock in CO2 emissions increases both of economic growth and energy consumption, and we find that a positive shock in energy consumption has a very small positive impact on economic growth and a high negative impact on CO2 emissions.

**Keywords :**CO2 emissions, energy consumption, Growth, SVAR.

الملخص:
يهدف هذا البحث إلىتحليل العلاقة بين استهلاك الطاقة والنمو الاقتصادي وانبعاثات ثاني أكسيد الكربون في الجزائر للفترة **1970-2017**، نستخدم لأجل ذلك نهج VAR الهيكلي القائم على BLANCHARD وQUAH(1989)، تظهر نتائج اختبارات جذر الوحدة أن جميع المتغيرات ثابتة في شكل الاختلاف الأول وتحليل التكامل المشترك الذي تم تحليله من خلال JOHANSEN-JUSELUIS (1990)، يظهر أنه لا يوجد دليل على التكامل المشترك بين متغيرات الاختبار ، تكشف نتائج هذه الدراسة أن الصدمة الإيجابية في انبعاثات ثاني أكسيد الكربون تزيد من النمو واستهلاك الطاقة ، ونجد أن الصدمة الإيجابية في استهلاك الطاقة لها تأثير إيجابي صغير جدًا على النمو الاقتصادي وتأثير سلبي كبير على انبعاثات ثاني أكسيد الكربون.

الكلمات المفتاحية:انبعاثات ثاني أكسيد الكربون ، واستهلاك الطاقة ، والنمو الاقتصادي، SVAR.

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**Résumé:**

Cette revue analytique explore les relations entre la consommation d'énergie, la croissance économique et les émissions de CO2 en Algérie pour la période 1970-2017, nous utilisons une approche VAR structurelle basée sur le travail de Blanchard et Quah (1989), les résultats des tests de racine unitaire montrent que toutes les variables sont stationnaires dans la première forme de différence et l'analyse de co-intégration analysée par Johansen-Juseluis (1990), montre qu'il n'y a aucune preuve de co-intégration parmi les variables de test. Les résultats de cette étude révèlent qu'un choc positif dans les émissions de CO2 augmente à la fois la croissance et la consommation d'énergie, nous constatons aussi qu'un choc positif dans la consommation d'énergie a un impact positif très faible sur la croissance économique et un impact négatif élevé sur les émissions de CO2.

**Mots-clés:Emissions de CO2, Consommation d'énergie, Croissance, SVAR.**

## 1. Introduction :

Since 1992 and the United Nations Framework Convention on Climate Change UNFCCC that commits state parties to reduce greenhouse gas emissions, the increasing threat of global warming and climate change has been a major concern of all the nations and organizations around the world during the last two decades; as said by Pao and Tsai (2011a) "the Climate Change has been one of the most critical global environmental challenges which are the top priority in the international political agenda", greenhouse gas emissions (GHG) especially carbon dioxide CO2 emissions are considered to be the main cause of global warming, in order to prevent global warming several countries have signed the Kyoto Protocol and promised to decrease their emissions levels, This in turn calls for a clear-identification of the sources of CO2 emissions (Soytas et al, 2007), this protocol demands reduction of the greenhouse gas emissions by 5.2% from the level of the 1990 during the period 2008-2012 (Kumar. T, 2011), and also the CO2 emissions due to the combustion of fossil fuels (Coal, Natural Gas and Oil) (Soytas and Sari, 2009), Halicioglu (2009) declared that CO2 emissions are the most important polluting gas by 58% of the GHG emissions worldwide.

**Table 1 :** Percentage changes in emissions with Kyoto targets.

| Country/ region | Kyoto target 2008-2012 | Kyototarget 2013-2020 | GHGemissions 1990-2008 including LULUCF | GHGemissions 1990-2008excluding LULUCF | CO2emissionsfrom fuel combustiononly 1990-2000 |
|---|---|---|---|---|---|
| Belgium | -8 (-7.5) | -20 | -6.2 | -7.1 | -6.7 |
| North America | - | - | - | - | +20.4 |
| France | -8 (0) | -20 | -12.7 | -5.9 | +0.6 |
| Germany | -8 (-21) | -20 | -17.6 | -21.4 | -21.1 |

| | | | | | |
|---|---|---|---|---|---|
| Italy | -8 (-6.5) | -20 | +0.4 | +4.7 | -2.0 |
| United Kingdom | -8 (-12.5) | -19.0 | -18.5 | -15.2 | |
| Australia | +8 | -0.5 | +33.1 | +31.4 | +51.8 |
| Japan | -6 | - | -0.2 | +1.0 | +2.7 |
| Russian Federation | 0 | - | -52.8 | -32.8 | -29.7 |
| Ukraine | 0 | -24 | -52.2 | -53.9 | -62.7 |

**Source :**UNFCCC 2011, p. 7.

### 1.1. Problematic study:

The aim of this paper is to investigate econometrically the links between energy consumption, economic growth and CO2 emissions in Algeria for the period 1970-2017, we use a structural VAR approach based on Blanchard and Quah (1989), to have a clear idea about relationships between the three variables; This study seeks to analyze the effects of an economic growth and energy consumption shocks on CO2 emissions by applying a VAR approach.

### 1.2Literature review:

The relationship between Energy Consumption (EC), Economic growth and environmental pollution (CO2 emissions) has been the subject of various and many articles during the last 30 years.

Halicoglu (2009) attempts to empirically examine the dynamic causal relationships between carbon emissions, energy consumption, income and foreign trade in the case of Turkey using the time series data for the period 1960-2005, by using the bounds testing to co-integration procedure (ARDL approach), the results indicate that there exist two forms of long-run relationships between the variables, and suggest that income is the most significant variable in explaining the carbon emissions then the energy consumption and foreign trade, Moreover, there exists a stable carbon emissions function. The results also provide important policy recommendations, The results of this study along with the studies of Tunc et al. (2007) and Telli et al. (2008) and shows that Turkey should design new environ-mental policies to reduce environmental degrading.

Soytas et al (2007) investigates the effect of energy consumption and output on carbon missions in the United States by using Granger causality for the period 1960-2004, by using annual data on real GDP and gross fixed capital formation (both in constant 2000 US$), total labor force, energy use (kg of oil equivalent), and CO2 emissions (kt) for the period 1960–2004, all data are from World Development Indicators and are in natural logarithms, the results suggest that the income does not granger cause carbon missions but energy use does, so, income growth may not become a solution to environmental problems in the USA, Xing and Xiao (2009) investigate the existence and direction of granger causality between the three variables in China during the period 1960-2007 by applying a multivariate model combined the three variables and capital and urban population, the results indicate a unidirectional granger causality running from GPD to energy consumption also from energy consumption to carbon missions, and the evidence shows that neither carbon emissions nor energy consumption leads economic growth, Therefore, the

Government of China can purse conservative energy policy and carbon emissions reduction policy in the long run without impeding economic growth.

Hsiao and Chung (2010) examine the dynamic causal relationships between the three variables for a panel of BRIC countries (Brazil, Russia, India and China) over the period 1971-2005 except for Russia (1990–2005), Panel co-integration techniques were applied to estimate emissions and to examine the energy consumption and real output sensitivity issues of both long-run and short-run emissions, the results shows that in long-run equilibrium energy consumption has a positive and statistically significant impact on emissions, while real output exhibits the inverted U-shape pattern associated with the Environmental Kuznets Curve (EKC) hypothesis with the threshold income of 5.393 (in logarithms), the panel causality results indicate that there are energy consumption–emissions bidirectional strong causality and energy consumption–output bidirectional long-run causality, along with unidirectional both strong and short-run causalities from emissions and energy consumption, respectively, to output.

Apergis and Payne (2010) examine the causal relationships between carbon dioxide emissions, energy consumption and real output within a panel vector error correction model (Panel VECM) for 11 countries of the commonwealth of Independent States over the period 1992–2004, they found that energy consumption has a positive significant impact on carbon emissions in the long-run term while real output follows an inverted U-shape pattern associated with the Environmental Kuznets Curve (EKC) hypothesis, and the results suggest that there is a bidirectional causality between energy consumption and CO2 emissions in the long run, but the short run dynamics reveal a unidirectional causality from energy consumption and real output to carbon dioxide emissions and bidirectional causality between energy consumption and real output.

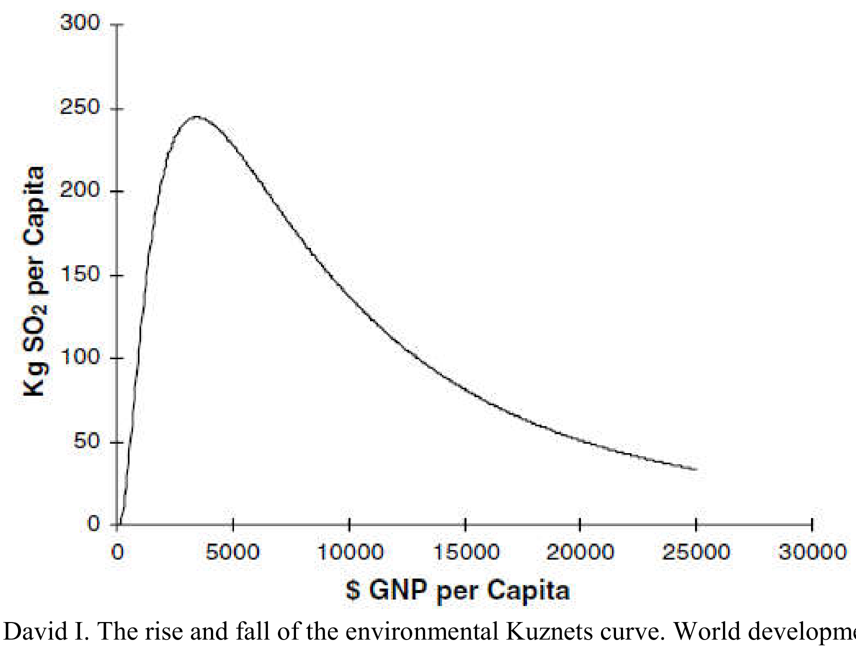
Acaravci and Ozturk (2010) examine the causal relationships between carbon dioxide emissions, energy consumption and economic growth by using an autoregressive distributed lag (ARDL) bounds testing approach of co-integration for 19 European countries, the test yields evidence of a long-run relationship between CO2 emissions per capita, energy consumption per capita, real GDP per capita and the square of per capita real GDP only for 7 countries (Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland), and the results support that the validity of the EKC hypothesis only in Denmark and Italy.

Al-Mulali (2011) examines the impact of Oil consumption on the economic growth in MENA countries for the period 1980-2009 using panel data, it has founded that CO2 emissions and oil consumption has a long-run relationship with economic growth, and there is a bidirectional causality between the three variables in both the short-run and the long-run terms, Arouri et al (2012) investigates the relationship between the variables for 12 MENA countries by implementing bootstrap panel and co-integration techniques, the results show that energy consumption has a positive impact on CO2 emissions for the region as a whole, and the EKC hypothesis is satisfied for the most studied countries, Farhani and Ben Rejeb (2012) by using panel data for 15 MENA countries examine the relationship between the three variables and the results show that there is no causality between GDP and energy consumption and between CO2 emissions and EC in the short run, However, in the long run, there is a unidirectional causality running from GDP and CO2 emissions to energy consumption, Kuo et al (2014) examine the granger causality relationship between the variables in Hong Kong for the period 1965-2010, The results indicate that there is a unidirectional causality running from CO2 emissions to energy consumption and CO2 emissions to GDP in Hong Kong. Moreover, there is a bidirectional causality between GDP and energy consumption existing.

**1.3 the importance of the study:**

There are three important researches in this area (the relationship between economic growth, environmental pollutants and energy consumption EC), the first is what called Environmental Kuznets Curve (EKC) as a hypothesized relationship between various indicators of environmental degradation and income per capita, the EKC is named for Kuznets (1955) who hypothesized income inequality first rises and then falls as economic development proceeds as U-shape Curve (Stern, 2003), whereas environmental degradation increases with per capita income during the early stages of economic growth, and then declines with per capita income after arriving at a threshold (Xing and Xiao, 2009).

**Figure 1** : Environmental Kuznets curve for sulfur emissions




**Source:** STERN, David I. The rise and fall of the environmental Kuznets curve. World development, 2004, vol. 32, no 8, p. 1419-1439.

Successive studies have tested the environmental pollution and economic growth nexus as Bruyn and Opschoor (1997), Unruh and Moomaw (1998), Heil and Selden (1999), Taskin and Zaim (2000), Friedl and Getzner (2003), Coondow and Dinda (2008) and Menagri and Jena (2008) after the first study of Grossman and Krueger (1991). But as such study in each area the EKC model is criticized for lack of feedback from environmental pollutants to economic output as income is assumed to be an exogenous variables for example Arrow et al (1995), Holtz-Eakin and Selden (1995), Roberts and Grimes (1997), Hung and Shaw (2002), Hill and Magnani

(2002), Harbaugh et al (2002), Ganas et al (2003), Dinda (2004), Stern (2004) and Xing and Xiao (2009).

The second study is Kraft and J.Kratf (1978) study on the relationship between energy and GNP in Journal of Energy and Development, as a study on the CO2 emissions from fossil fuels by using bi-variate model for testing causality between the two variables, but this model is criticized by Stern (2003) because the failure to detect the Granger causality and also the co-integration, and he suggest that the multivariate models by added the gross domestic product (GPD), Capital and Labor Force is the optimal model to test the long-run relationships between the two variables and also the causality both in short-run and long-run term, See, e.g Masih and Masih (1998), Asafu-Odjaye (2000), Stern (2000), Getzner (2003) found an N-shaped curve, Ghali and El-Sakka (2004), Oh and Lee (2004), Kaufman (2006), Huang et al (2008), Ghosh (2010), Lau et al (2011), Binh (2011) and Kaplan et al (2011).

From the two previous researches strands, most of studies focus on the nexus growth-pollution or growth-energy, but in the last few years new studies implied to investigate the links between the three variables as a triangle energy-environment-income nexus, by of course applying multivariate models (soytas et al, 2007), see e.g Belloumi (2009), Lee and Chang (2008), Mehrara (2007), Narayan et al (2008), Soytas and Sari (2009), Kumar (2011), Farhani and Ben Rejeb (2012) and Kuo et al (2014).

**2. Case study:**

**2.1 Tool and study model:**

In this study, we analyze the impacts and the relationships between the economic growth, energy consumption and CO2 emissions in the context of Algeria by applying the SVAR approach instead of VAR procedure that analyze the dynamic impacts of different types of random shocks of the variables in the model, so we use the SVAR model to solve the traditional identification problem, by predicting the effects of specific policy actions or changes in the economy (Narayan et al, 2008), the SVAR model allows to the policy makers and economic forecasters to add new constraints to the VAR model to predict how some variables respond over the time to changes policies (Buckle et al, 2002), for this we adopt the Blanchard and Quah SVAR model (1989) to generate the variables shocks using this model:

$$GDP_t = \sum b^i_{11}\, GDP_{t-1} + b^0_{12}\, EC_t + \sum b^i_{12}\, EC_{t-1} + b^0_{13}CO2_t + \sum b^i_{13}CO2_{t-1} + \varepsilon_{1t}$$
$$EC_t = b^0_{21}GDP_t + \sum b^i_{21}\, GDP_{t-1} + \sum b^i_{22}\, EC_{t-1} + b^0_{23}CO2_t + \sum b^i_{23}CO2_{t-1} + \varepsilon_{2t} \qquad (1)$$
$$CO2_t = b^0_{31}GDP_t + \sum b^i_{31}\, GDP_{t-1} + b^0_{32}\, EC_t + \sum b^i_{32}\, EC_{t-1} + \sum b^i_{33}CO2_{t-1} + \varepsilon_{3t}$$

Where (GDPt, ECt and CO2t) are the economic growth, energy consumption and CO2 emissions, εit are independent white-noise disturbances, and the model can be written as follows:

$$\begin{bmatrix} GDPt \\ ECt \\ CO2t \end{bmatrix} = \begin{bmatrix} C11(L) & C12(L) & C13(L) \\ C21(L) & C22(L) & C23(L) \\ C31(L) & C32(L) & C33(L) \end{bmatrix} \begin{bmatrix} e1t \\ e2t \\ e3t \end{bmatrix} \qquad (2)$$

From the Blanchard and Quah's (1989) method, and in order to explain the bootstrapping procedure eq(2) can be:

$$Zt = A(L)\, Zt\text{-}p + \mu t\ ,\ \mu t \sim i.n.i.d \qquad (3)$$

Where Zt is a (3*1) vector of GDPt, ECt and CO2t and μt is a (3*1) vector of eit and μt , μt ~ i.n.i.d denotes errors that are independent but not necessarily identically distributed, we adopt the wild bootstrap method developed by Wu (1986) and Liu (1988) that focus on bootstrap rarely explored.

**2.2Data Analysis:**

The variables used in this study are Energy Consumption (EC) measured in kg of oil equivalent, GDP per capita measured in constant 2000 US$ and CO2 emissions measured in metric tons, all the variables are in logarithms form to reduce the heterogeneity of data, for the period 1970-2017 in Algeria.

**2.2.1 Unit test root:**

We use in this study three different unit root tests including ADF (Augmented Dickey Fuller), PP (Philips Perron) and NP (Ng and Perron), the results are reported in table 3.

**Table 3 :** Unit Test Roots results:

| Variables | ADF | PP | NP | |
|---|---|---|---|---|
| | | | (MZa) (k) | (MZt) (k) |
| LNCO2 | -4.14 | -4.26 | -6.62 | -1.77 |
| D(LNCO2) | -8.02*** | -9.23*** | -19.88** | -3.14** |
| LNEC | -1.92 | -1.94 | -1.94 | -0.97 |
| D(LNEC) | -6.15*** | -6.23*** | -20.33** | -3.18** |
| LNGDP | -4.06 | -2.03 | -2.16 | -1.02 |
| D(LNGDP) | -10.04*** | -8.74*** | -18.24** | -3.01** |
| Note: *** denotes significant at 10%,5% and 1% level. (K) denotes lag length (2) Selection of lag length in NP test is based on Spectral GLS-detruded AR based on SIC. | | | | |

**Source :** Authors calculation using Eviews 10.

It is evident from Table 3 that all variables are nonstationary in their level form, so all variables are stationary at the 5% significance level of the first difference, that is, all variables are I(1), therefore we can proceed for co-integration analysis using Johansen (1981) test for long-run relationship and Table 6 in the appendix showed that there is no co-integration relationship between the three variables, for analyzing the non-stationary series in a VAR system Ramaswamy and Sloek (1997) mentions three possible ways to specify, the first, either to specify the series in differenced form, second, to specify them in levels, and third to consider the co-integration relationships among the test variables by applying a vector error correction model (VECM) when the co-integration relationship is known, but if the co-integration relationship is unknown, VECM can be biased and it could be more appropriate to consider the VAR in levels, so we use a SVAR model as we do not have co-integrating relationship among the test variables.

**2.2.2 Optimum lag length:**

The second step in VAR estimation is to investigate the optimum lag length (P) chosen by sequential modified Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike criterion (AIC), Shwarz criterion (SC) and Hannan-Quinn criterion (HQ), the table 4 reports the optimum lag length (P=1) out of a maximum of 8 lag lengths as selected by LR, FPE and AIC.

**Table 4 :** Lag length selection

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 60.99730 | NA | 8.00e-06 | -3.222072 | -3.090113 | -3.176015 |
| 1 | 177.2796 | 206.724* | 2.07e-08* | -9.182197 | -8.65435* | -8.99796* |
| 2 | 184.7622 | 12.05535 | 2.28e-08 | -9.097899 | -8.174180 | -8.775496 |
| 3 | 187.2802 | 3.637178 | 3.37e-08 | -8.737790 | -7.418191 | -8.277215 |
| 4 | 195.5086 | 10.51401 | 3.72e-08 | -8.694921 | -6.979442 | -8.096173 |
| 5 | 208.8837 | 14.86126 | 3.22e-08 | -8.937984 | -6.826626 | -8.201064 |
| 6 | 217.7633 | 8.386240 | 3.79e-08 | -8.931293 | -6.424054 | -8.056199 |
| 7 | 231.7445 | 10.87431 | 3.66e-08 | -9.208029 | -6.304911 | -8.194763 |
| 8 | 241.4480 | 5.929889 | 5.12e-08 | -9.24711* | -5.948112 | -8.095671 |

*: indicates lag order selected by the criterion.

**Source:** Authors calculation using Eviews 10.

## 2.2.3 VAR estimation:

After select the optimal lag length we estimate the following VAR(1) model:

$$LNGDPt = \alpha 1t + \sum_{k=1}^{c} . LNGDPt\text{-}j + \sum_{i=1}^{h} . \beta\ 1t\ LNCO2t\text{-}i + \sum_{j=1}^{l} . y\ 1t\ LNECt\text{-}j + \varepsilon 1t$$

$$ECt = \alpha 2t + \sum_{j=1}^{l} . y\ 2t\ LNECt\text{-}j + \sum_{i=1}^{h} . \beta\ 2t\ LNCO2t\text{-}i + \sum_{k=1}^{c} . LNGDPt\text{-}k + \varepsilon 2t \quad (4)$$

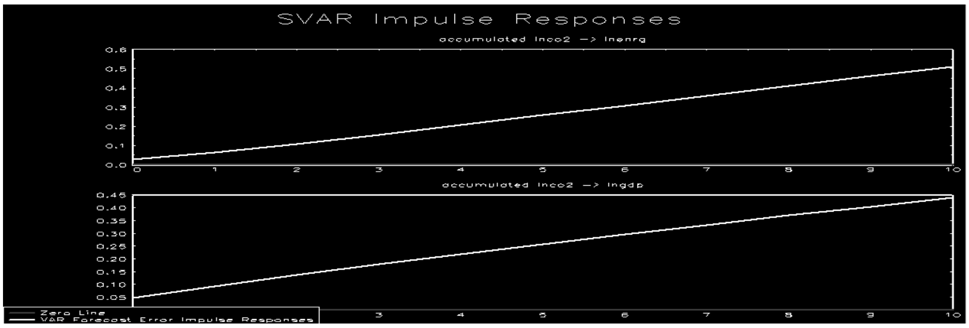
$$LNCO2t = \alpha 3t + \sum_{i=1}^{h} . \beta 3t\ \ LNCO2t\text{-}I\ + \sum_{j=1}^{l} . y3t\ LNECt\text{-}j + \sum_{k=1}^{c} .LNGDPt\text{-}k + \varepsilon 3t$$

The results in Figures 3 and 4 in appendix presents the plot of CUSUM and CUSUMSQ tests statistics that fall inside the critical bounds of 5% significance, this implies that the estimated parameters are stable over the periods.

## 2.2.4The SVAR Estimation:

Following Benkwitz et al (2001) who suggest that for small sample, properties of bootstrap confidence intervals are better in comparison to other asymptotic methodologies, we have computed bootstrap percentile 95% confidence intervals (see, e.g Hall (1992) and Efron and Tibshirani (1993)) with 1000 bootstrap replications to illustrate parameter uncertainty to get estimated contemporaneous impact matrix and the estimated identified long run impact matrix (Figure 5), The horizon of all responses is 10 years.

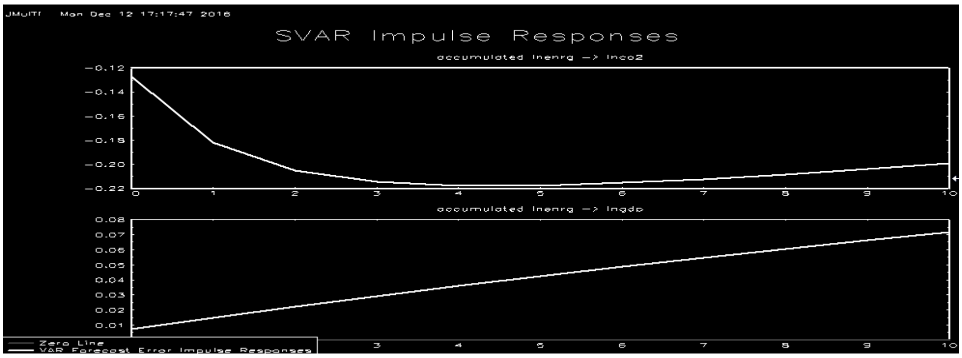
**Figure 2a :** Structural impulse response functions for LNCO2




**Source:** Authors calculation using Jmulti4.

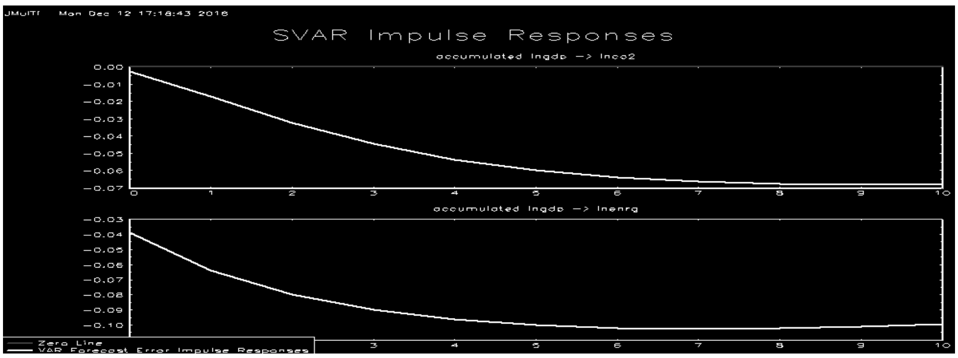
It is evident from Figure 2a that any one positive standard deviation shock to LNCO2 has very high and increasing positive impact on both the LNGDP and LNEC for all the 10 periods (from 6.3% and 9.2% for the short-run response to 25.7% and 25.8% in medium term until 50.9% and 43.9% in the long- run term see table 7 in appendix), from figure 2b it is evident that any one positive standard deviation shock to LNEC has a very high and increasing negative impact on LNCO2 until the 4th period then the response Stabilizes between -21% and -19% in the long-run term, the same deviation (shock) has an increasing small positive impact on the LNGDP for all the periods from 1.5% in the short-run to 7.1% in the long-run term, from figure 2c it is evident that any one positive standard deviation shock to LNGDP has a very high and increasing negative impact on both LNCE and LNCO2 until the 6th period for LNCE and the 10th period for the LNCO2.

**Figure 2b :** Structural impulse response functions for LNCE




**Source:** Authors calculation using Jmulti4.

**Figure 2c :** Structural impulse response functions for LNGDP




**Source:** Authors calculation using Jmulti4.

Further, we have analyzed the variance decomposition and the essence of the variance decomposition or forecast error variance decomposition (FEVD) is that it measures the proportion of forecast error variance in one variable explained by innovations in itself and the other variables; it determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks of the other variables, do one shock to an individual variable can affect both own changes and changes in the other variables (Ewing et al., 2007), and Table 5 shows the results:

**Table 5 :** Variance Decompositions (VDs) analysis

| Proportions of forecast error in LNEC accounted for by: | | | |
|---|---|---|---|
| forecast horizon | LNCO2 | LNEC | LNGDP |
| 1 | 0.11 | 0.89 | 0.00 |
| 3 | 0.16 | 0.82 | 0.02 |
| 5 | 0.21 | 0.76 | 0.03 |
| 8 | 0.30 | 0.67 | 0.03 |
| 10 | 0.35 | 0.63 | 0.02 |
| Proportions of forecast error in LNGDP accounted for by: | | | |
| forecast horizon | LNCO2 | LNEC | LNGDP |
| 1 | 0.30 | 0.03 | 0.67 |
| 3 | 0.62 | 0.01 | 0.37 |
| 5 | 0.77 | 0.01 | 0.22 |
| 8 | 0.86 | 0.01 | 0.13 |
| 10 | 0.88 | 0.01 | 0.10 |
| Proportions of forecast error in LNCO2 accounted for by: | | | |
| forecast horizon | LNCO2 | LNEC | LNGDP |
| 1 | 0.97 | 0.02 | 0.01 |
| 3 | 0.97 | 0.03 | 0.01 |
| 5 | 0.97 | 0.03 | 0.01 |
| 8 | 0.97 | 0.03 | 0.01 |
| 10 | 0.97 | 0.03 | 0.01 |

**Source :** Authors calculation using Jmulti4.

It is evident from Table 5 that in the short-run term (1st and 3rd period) LNEC itself explains 89% and 82% respectively of forecast error in its own value and 18% by LNCO2 (16%) and LNGDP (2%), and the explanation of LNCO2 rises until 35% in the long-run term with the fall of LNCE itself explanation to 65% when the explanatory power of LNGDP has not increased in this duration; Further, the results shows that a large proportion of forecast error variations in LNGDP are explained by LNCO2 (30% in the short-run and 88% in the long-run term) and the LNCE explains a very less of forecast error variation in LNGDP (3%) both in short-run and long-run terms, In addition, we find that larger proportion of forecast error variations in LNCO2 are explained by its of value (97% both in short-run and long-run terms)( see Figure 5).

**3. Conclusion and Discussion of the results:**

The principal aim of this paper was to seek for the relationships between energy consumption measured in kg of oil equivalent, economic growth measured as GDP per capita in constant 2000 US$ and CO2 emissions measured in metric tons in the case of Algeria during the period starting from 1970 to 2017, we employed in this study the SVAR model (Structural Vector Autoregressive) based on Blanchard and Quah (1989) approach according to structural impulse response functions (SIRF) and structural variance decomposition (SVD), From the co-integration test results, we found that there is no co-integration relationship between the three variables, the results of SIRF revels that a positive shock in CO2 emissions increases both of economic growth and energy consumption, Further, we find that a positive shock in energy consumption has a very small positive impact on economic growth for all the period (10 years) and has a high negative impact on CO2 emissions until the 6th period, in addition we find that a positive shock in economic growth has a very small negative impact CO2 emissions and energy consumption, The results of structural variance decomposition approach shows that the major portion of CO2 emissions is explained by its own value; Further, the results shows that a large proportion of forecast error variations in LNGDP are explained by LNCO2, the results suggests also that the share of CO2 emissions in the long-run term explained a significant part of the forecast error variations of energy consumption.

**Appendix:**

**Table 6 :** co-integration test (Johansen procedure)

| Unrestricted Co-integration Rank Test (Trace) | | | | |
|---|---|---|---|---|
| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
| None | 0.325382 | 27.45390 | 29.79707 | 0.0581 |
| At most 1 | 0.290024 | 14.88520 | 15.49471 | 0.0616 |
| At most 2 | 0.011815 | 0.499164 | 3.841466 | 0.4799 |
| **MacKinnon-Haug-Michelis (1999) p-values | | | | |

**Source :** Authors calculation using Eviews 10.

**Figure 3:** VAR estimation:

```
Lagged endogenous term:
=======================
                    lnco2       lnenrg       lngdp
-------------------------------------------------------
lnco2  (t-1)|      0.450        0.048       -0.002
            |     (0.120)      (0.042)      (0.042)
            |     {0.000}      {0.255}      {0.960}
            |     [3.751]      [1.138]     [-0.050]
lnenrg(t-1)|      0.350        0.682        0.016
            |     (0.258)      (0.090)      (0.091)
            |     {0.174}      {0.000}      {0.863}
            |     [1.358]      [7.547]      [0.173]
lngdp  (t-1)|      0.024        0.380        0.952
            |     (0.358)      (0.125)      (0.127)
            |     {0.946}      {0.002}      {0.000}
            |     [0.067]      [3.032]      [7.521]
-------------------------------------------------------

Deterministic term:
===================
               lnco2      lnenrg       lngdp
-----------------------------------------------
CONST     |    3.426     -7.981        1.163
          |   (7.474)    (2.619)      (2.645)
          |   {0.647}    {0.002}      {0.660}
          |   [0.458]   [-3.047]      [0.440]
-----------------------------------------------
```

**Source :** Authors calculation using Jmulti4.

Figure 4: estimated contemporaneous impact matrix and the estimated identified long run impact matrix:

$$A = \begin{bmatrix} 1.000 & 0.000 & 0.000 \\ -0.0064 & 1.000 & 0.000 \\ 0.1061 & -0.3902 & 1.000 \end{bmatrix} \qquad B = \begin{bmatrix} 6.7163 & 0.000 & 0.000 \\ 0.000 & 0.9777 & 0.000 \\ 0.000 & 0.000 & 4.8540 \end{bmatrix}$$

**Source :** Authors calculation using Jmulti4.

**Table 7 : structural** impulse response results

| LNCO2 shock | LNEC | LNGDP |
|---|---|---|
| point estimate | 0.0259 | 0.0471 |
| 1 point estimate | 0.0636 | 0.0923 |
| 4 point estimate | 0.2061 | 0.2185 |
| 5 point estimate | 0.2573 | 0.2580 |
| 8 point estimate | 0.4107 | 0.3696 |
| 10 point estimate | 0.5097 | 0.4389 |
| LNEC shock | LNCO2 | LNGDP |
| point estimate | -0.1277 | 0.0074 |
| 1 point estimate | -0.1819 | 0.0149 |
| 4 point estimate | -0.2180 | 0.0359 |
| 5 point estimate | -0.2177 | 0.0424 |
| 8 point estimate | -0.2084 | 0.0605 |
| 10 point estimate | -0.1995 | 0.0717 |
| LNGDP shock | LNCO2 | LNEC |
| point estimate | -0.0025 | -0.0389 |
| 1 point estimate | -0.0171 | -0.0636 |
| 4 point estimate | -0.0536 | -0.0964 |
| 5 point estimate | -0.0599 | -0.1001 |
| 8 point estimate | -0.0676 | -0.1021 |
| 10 point estimate | -0.0677 | -0.0995 |

**Source :** Authors calculation using Jmulti4.

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