CO_2 EMISSION AND ECONOMIC GROWTH IN ALGERIA

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ABSTRACT

Algeria is one of the most important CO_2 emitters among developing countries and the third among African countries. It pledged to curb carbon emissions by at least 7% by 2030. However, complying with this target may be a difficult task without compromising economic growth. The aim of this paper is to analyze the relationship between CO_2 emissions and economic growth in Algeria, taking into account energy use, electricity consumption, exports and imports. The validity of the EKC hypothesis, throughout the period from 1970 to 2010, is tested by using the Autoregressive Distributed Lag model extended to introduce the break points. Results confirm the EKC for Algeria. Nevertheless, the turning point is reached for a very high GDP per capita value, indicating that economic growth in Algeria will continue to increase emissions. Results also indicate that an increase in energy use and electricity consumption increase CO_2 emissions, and that exports and imports affect them negatively and positively, respectively. Therefore, it is necessary to promote renewable energies and energy efficiency policies. Regulatory reforms are needed to facilitate foreign investments with which to carry out these policies. Likewise, it may be appropriate to decrease subsides in energy prices to encourage energy efficiency.

Keywords: CO2 emissions, Economic growth, Environmental Kuznets Curve, ARDL model,

JEL code: Q56, O49, O55, C20

Highlights

- Algeria pledged to curb carbon emissions by at least 7% by 2030
- EKC is tested by using the ARDL model with breakpoint for 1970-2010
- Results show that EKC is confirmed but the threshold level of income is not reached yet.
- Results indicate that energy use and electricity consumption increase emissions

Exports and imports affect emissions negatively and positively, respectively

CO_2 EMISSION AND ECONOMIC GROWTH IN ALGERIA

1. Introduction

Algeria is one of the most important CO_2 emitters among developing countries and the third among African countries (Sahnoune et al., 2013). It emitted a total of 147 MtCO2 in 2014, being 34th in the fossil fuel emissions world ranking of countries, and sixth in CO_2 emissions from gas flaring (Olivier el al., 2015). Additionally, Algeria is particularly vulnerable to the multiform effects of climate change, with its yearly average rainfall having declined by more than 30% over the past decades. Moreover, land characteristics, mainly dessert areas, reduce the possibilities of carbon capture (INDC, 2015). In that sense, Algeria has been one of the countries with special interest in signing the COP21 agreement. In fact, it was one of the developing countries which first submitted the Intended Nationally Determined Contribution (INDC) to the UN Framework Convention on Climate Change. The Algerian INDC pledged to curb carbon emissions by at least 7%, compared to business-as-usual levels by 2030.

Nevertheless, Algeria may has a very complicated task if it wants to meet the targets set in its INDC, and at the same time grow and improve the standard of living of its inhabitants, especially because it is specialized in exports of natural resources. The Algerian economy is characterized by its high dependence on oil exports (more than 97% of all exports in 2013), and is the sixth-largest gas exporter (CIA World Factbook, 2015). Additionally, its economy is characterized by a poorly diversified production, which means that this country has been dominated by gas extracting industries. Also, as stated in Omri (2013), countries such as Algeria tend to greatly increase their CO_2 emissions as they try to industrialize and modernize the economy, as significantly boosting the economic growth leads to the consumption of high quantities of energy which is sourced mainly from oil and gas. On the one hand, the production of gas and oil is increased to meet the growing energy needs of households and local industries, which tend to be high as industries in oil countries are usually energy-intensive (Damette and Seghir, 2013). On the other hand, the production of gas and oil is augmented to increase exports to obtain financial resources for investing in the industrial sector.

Therefore, the analysis of the relationships between emissions and economic growth in this developing country is of interest. In this sense, testing the validity of the Environmental Kuznets Curve (EKC) hypothesis is crucial because, as stated by Narayan and Narayan (2010), this allows policymakers to judge the response of the environment to economic growth. Thus, the results of this study may help the Algerian policymakers to establish an energy policy that guarantees a balance between economic growth and environmental prosperity.

Since Panayotou (1993) introduced the term “Environmental Kuznets Curve", there has been increasing attention on the impact of economic growth on the environment (Stern, 2014). The studies investigated different countries or panels of countries from all regions of the world (Al-Mulali et al., 2015). Nevertheless, less attention has been given to smaller emerging countries, especially in the MENA region and Africa (Soytas and Sari, 2009; Osabuohien et al., 2014). To our knowledge there is just one previous study referring to Algeria (Lacheheb et al., 2015). This study analyses the relationships between CO2 emissions and economic growth by comparing the short and long-run elasticities as in Narayan and Narayan (2010). Three CO2 resources are used to measure emissions. However, total emissions and energy use have not been included in the model. Additionally, two previous panel data analyses also provide the short run and long run estimates for Algeria (Narayan and Narayan, 2010 and Arouri et al., 2012), although they do not take into account specific characteristics of the Algerian economy, such as trade characteristics.

Following these previous studies, the aim of this paper is to analyze the relationships between CO2 emissions and economic growth in Algeria, taking into account the country characteristics (trade and energy use), by testing the validity of the EKC hypothesis throughout the period from 1970 to 2010. The traditional quadratic approach rather than the Narayan and Narayan (2010) approach has been used to investigate the EKC hypothesis. This method allows the value of the EKC turning point to be calculated, if it exists. Therefore, this paper contributes to enlarging the EKC literature referring to African countries and Algeria, for which there are scarce studies.

The EKC is tested by analyzing the relationship between the CO_2 emissions and real GDP per capita, real GDP per capita squared and others variables which may affect CO_2 emissions. The EKC has been tested by taking into account energy use, as this variable has been included in several previous studies, such as those by Li et al. (2016), Al-Mulali and Ozturk (2015), Shahbaz et al. (2014) and Arouri et al. (2012). Nevertheless, few studies have used electricity consumption, for example in Al-Mulali and Ozturk (2015), in which it was considered that it may reflect changes in lifestyle (Cowan et al, 2014). Therefore, in addition to energy use, electricity consumption has also been considered. The EKC hypothesis has also been tested taking into account trade openness, as in previous studies such as Halicioglu (2009) and Onafowora and Owoye (2014). Usually, trade openness has been measured as exports plus imports with respect to GDP, although recently Al-Mulali et al. (2015) used the exports and imports of goods and services separately, with the aim of further elucidating the relationship between the variables and CO_2 emission. In this paper, exports and imports with respect to GDP are considered separately as both magnitudes may have different effects on emissions, because Algerian exports are, as stated before, mainly related to fossil fuel.

The methodology adopted is the application of the Autoregressive Distributed Lag (ARDL) model extended to introduce the break points. The inclusion of these break points seems to be necessary as the evolution of GDP in Algeria, as stated in Belaid and Abderrahmani (2013), shows different growth patterns from 1970 to 2010, related to political decisions, which are observed mainly in the 1980s.

The remainder of this paper is organized as follows. In Section 2, a literature review is presented. In Section 3, the methodology is explained. In Section 4, a descriptive analysis is made and the statistical information sources used are specified. In Section 5, the results are presented and discussed. Finally, the main conclusions and policy implications are given in Section 6.

2. Literature review

The EKC concept emerged in the early 1990s with the Grossmann and Krueger (1991) research on the environmental impacts of the North American Free Trade Agreement, and with the study by Shafik and Bandyopadhyay (1992) for the World Development Report 1992. Later, Panayotou (1993) was the first to introduce the term “Environmental Kuznets Curve" in the economics literature. Since then, there has been increasing attention on the impact of economic growth on the environment, with a very large empirical literature on the EKC. Reviews of this topic can be found in Kijima et al. (2010), Koirala et al. (2011), Kaika and Zervas (2013) and Stern (2014). Additionally, Al-Mulali et al. (2015) recently reviewed the empirical studies published over the period 2003–2014. The previous studies may be divided into two categories. The first examines the EKC for individual countries, while the second tests the EKC for a cross-section and/or panel of countries.

The studies investigated different countries from different world regions, mainly from East Asia and the Pacific, South Asia, the Americas, Europe and Central Asia, Middle East and North Africa (MENA) and Sub-Saharan Africa (Al-Mulali et al., 2015). Nevertheless,

less attention has been given to smaller emerging countries, especially in the Middle East and North Africa region (MENA) (Soytas and Sari, 2009) and in Africa (Osabuohien et al., 2014).

Among the studies referring to individual MENA countries, most refer to Tunisia (M'henni, 2005; Fodha and Zaghdoud, 2010; Shahbaz et al., 2014; Farhani et al., 2014b), and to Turkey (Akbostanci et al., 2009; Ozturk, and Acaravci, 2010; Tutulmaz, 2015). Among the studies referring to a panel of countries including some MENA countries, Narayan and Narayan (2010) tested the EKC hypothesis for 43 developing countries, including 12 Middle Eastern and 12 African countries, finding that the CO_2 emissions have fallen with a rise in income only for the Middle Eastern and South Asian panels.

Additionally, some studies refer to a specific panel of MENA countries. Arouri et al. (2012) investigated the relationship between CO_2, energy consumption, and real GDP for 12 MENA countries (Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and the United Arab Emirates (UAE)) over the period 1981–2005. The results show poor evidence in support of the EKC hypothesis. Likewise, Ozcan (2013) tested the EKC hypothesis for 12 Middle East countries with abundant reserves of natural resources, as these countries attract a special interest for energy economists. The results provide evidence contrary to the EKC hypothesis, although an inverted U-shaped curve was identified for 3 Middle East countries. Farhani and Shahbaz, (2014), tested the EKC by using a panel data of 10 MENA countries. The authors examined the relationship between CO_2 emissions, economic growth, and renewable and non-renewable electricity consumption, for the period 1980–2009. The results provide evidence for the EKC hypothesis in those countries. Likewise, Farhani et al. (2014a) studied two different EKC specifications for 10 MENA countries over the period 1990–2010 using panel data methods, including sustainability, human development, energy, trade, manufacture added value and the role of law.

In relation to other African countries, most of them refer to South Africa. Thus, Kohler (2013) analyzed the relationships between CO_2 emissions, energy consumption, income and foreign trade to test the validity of the EKC hypothesis, over the period 1960–2009. The results show that energy use raised CO_2 emission levels, while higher levels of trade reduced them. Also for South Africa, Shahbaz et al. (2013a) studied the effects of financial development, economic growth, coal consumption and trade openness on the environment, during the period 1965–2008. The authors found evidence of the existence of the EKC. Likewise, Nasr et al. (2015) tested the EKC for South Africa using a century of data (1911–2010). Nevertheless, the authors provided no support for the EKC.

Other studies referring to African countries refer to Sub-Saharan Africa (Kivyiro and Arminen, 2014; Shahbaz et al., 2015). The first investigated the relationships between CO_2 emissions, energy consumption, economic development and foreign direct investment in six Sub Saharan African countries. The results support the EKC hypothesis in the Democratic Republic of the Congo, Kenya and Zimbabwe. The second study explored the dynamic link in emissions, energy intensity and economic growth for 13 African countries, over the period 1980–2012, supporting the presence of the EKC. Additionally, the study by Oshin and Ogundipe (2014) tested the EKC for a panel of 15 West Africa countries for the period 1980-2012. The results confirmed the EKC in the region. In addition, the study by Osabuohien et al. (2014) referred to a panel of 50 African countries, using data from 1995–2010. In order to test the EKC, institutional quality and trade openness variables were included. The results confirmed the existence of an inverted 'U-shaped' trend in the relationship between CO_2 emissions and economic development. Finally, the study by Al-Mulali et al. (2016) tested the EKC for Kenya in the period 1980–2012, also finding that the EKC hypothesis held.

Despite the recent increasing interest in African countries, to our knowledge there is just one previous study referring to Algeria (Lacheheb et al., 2015). This study investigates the EKC for the period 1971-2009 by comparing short-run and long-run models. Three CO_2 resources (CO_2 emission from solid fuel consumption, from liquid fuel consumption, and from electricity and heat production) are alternatively used to measure emissions. However, total emissions and energy used have not been considered in the model specification. The authors provided no support for the EKC.

Likewise, Narayan and Narayan (2010) and Arouri et al. (2012) also provide the Algerian short run and long run estimates in their panel data studies. The first is the study by Narayan and Narayan (2010), which tested the EKC for the period 1980–2004 by comparing the long run and short run income elasticity and found that emissions have fallen with a rise in income in Algeria. In the study by Arouri et al. (2012), the authors implemented bootstrap unit root tests and panel cointegration techniques to investigate the EKC over the period 1981–2005, finding an EKC for Algeria, although it did not reach the threshold point. Nevertheless, these studies do not take into account specific characteristics of the Algerian economy, such as its trade characteristics.

Following these previous studies, in this paper the ECK in Algeria is tested by using a traditional quadratic form in which others variables have been taken into account. The empirical studies that test the EKC hypothesis have been using a general model in which the variable of environmental degradation, usually CO_2 emissions, depends on the independent variable of income, its squared value, and some other variables (Dinda, 2004). Among these variables, as stated in Shahbaz et al. (2013b), the EKC literature mostly uses energy indicators and trade openness as a control variable to omit specification bias.

The energy economics empirical literature includes an energy indicator as a determinant of CO_2 emissions while testing the EKC. Most of these studies include energy consumption as an indicator of CO_2 emissions, following the initial study by Ang (2007). Among them may be highlighted the studies by Soytas et al. (2007) for the United States, Apergis and Payne (2009) for Central America, Zhang and Cheng (2009) and Wang et al. (2011) for China, Halicioglu (2009) and Ozturk and Acaravci (2010) for Turkey, Pao and Tsai (2011) for Brazil, Alam et al. (2012) for Bangladesh, and Kasman and Duman (2015) for new EU member and candidate countries. Additionally, energy consumption has been included in studies referring to a panel of MENA countries, such as in Farhani et al. (2014a), Arouri el al (2012), and also in the study by Omri (2013), which examined the nexus between CO_2 emissions, energy consumption and economic growth by using simultaneous-equations models. These studies show a positive effect of energy use on CO_2 emissions.

Some other studies have included other energy indicators. The studies by Tiwari et al. (2013) and Shahbaz et al. (2013a), include coal consumption, the study by Lotfalipour et al. (2010), includes fossil fuel consumption, the study by Iwata et al. (2010), analyses the role of nuclear energy in France. Surprisingly, as stated in Bento et al. (2016), the literature remains scarce with regard to electricity. Only a very few studies have considered electricity consumption, dividing it into renewable and non-renewable electricity consumption, with Cowan et al. (2014), Farhani and Shahbaz. (2014), Al-Mulali and Ozturk (2015) and Bento et al. (2016) among them. In this paper, energy use and also electricity consumption have been included as determinants of CO_2 emissions.

Moreover, several authors have argued that factors such as trade can also affect the EKC hypothesis (Kaika and Zervas, 2013). Thus, trade openness has been included as an independent variable when testing the EKC in previous studies, although contradictory results were established. Halicioglu (2009) found foreign trade significant in the case of Turkey. Jalil and Feridun (2011) included the openness ratio as a proxy for foreign trade when testing EKC for China, also being beneficial for the environment. Along the same line, the study by Shahbaz et al. (2013a) found that trade openness decreased CO_2 emissions in South Africa. Others, however, consider that trade is harmful for the environment. Thus, Ozturk and

Acaravci (2013) found that an increase in foreign trade to GDP ratio resulted in an increase in per capita carbon emissions in Turkey. Likewise, the study by Osabuohien et al. (2014) showed that the coefficient for the trade variable is negative, implying that increase in trade does not contribute to environmental pollution in Africa. Additionally, Onafowora and Owoye (2014) showed that that the sign of the coefficient that relates trade openness and emissions, differs across the countries of the sample, being negative for Brazil, China, Japan and South Africa, while positive for Egypt, Mexico, Nigeria and South Korea. Trade openness has been measured as the sum of exports and imports related to GDP. Nevertheless, recently Al-Mulali et al. (2015) used both variables, the exports and imports of goods and services of the economy, in a separate manner. The authors showed that the relationship between these variables and CO_2 emissions differs. While imports of goods and services increase pollution, exports of goods and services have no effect. Following Al-Mulali et al. (2015) exports and imports are considered separately in this paper.

Continuing from the previous literature, the main contributions of this study are as follows. Firstly, this paper focuses on Algeria, for which, to our knowledge, there are no specific studies which use a traditional quadratic form to test the EKC. Focusing on Algeria may be interesting as it is a fuel exporter developing country which may reduce its emissions in order to comply with its INDC targets. Secondly, this paper enlarges the ECK literature on Africa, for which there are still few studies. Thirdly, the paper considers not only energy use, but also electricity consumption. Therefore it enlarges the EKC literature related to electricity consumption. Finally, the paper continues the initial consideration of the separate analysis of the effects of exports and imports on CO_2 emissions.

3. Methodology

In line with the previous studies, CO_2 emissions are defined as a function of GDP, the GDP squared and some additional variables: energy use or alternatively electricity consumption, exports and imports. If the elasticity of GDP is positive, and also that related to the GDP squared is negative, then it may be concluded that the EKC hypothesis is supported, and therefore emissions will increase until some threshold level of income is reached, after which emissions will decrease.

In this paper, energy use has been initially considered. Nevertheless, electricity consumption has been alternatively taken as a determinant of CO_2 emissions. Some reasons are behind this. Firstly, the electricity per capita growth rate was 477% from 1975 to 2010 in Algeria, while its energy use per capita growth rate was 245% in the same period, according to the World Bank database (2016a). Secondly, electricity demand is expected to more than double by 2030, while the hydrocarbons sector has experienced a significant decline in production since 2006 (Nachmany et al. 2015). Thirdly, 97.5% of the electricity is generated from fossil fuel (CIA World Factbook, 2015). Finally, the CO_2 per kWh of electricity generated using the electricity-specific method by Brander et al. (2011) is 0.66, this value being similar to African and non-OECD countries, but much larger than EU, North American and OECD countries. Therefore, as stated by Cowan et al. (2014), the relationship between electricity consumption and CO_2 emissions is important for the implementation of related policies.

Additionally, export and import variables, instead of trade openness, are also incorporated as determinants of CO_2 emissions, as in Al-Mulali et al. (2015). This difference may be appropriate for Algeria because of the high percentage of energy exports. In that sense, Algeria's economy is based primarily on the exports of gross fuel and oil products, which represents more than 97% of goods and services exports in 2010 (IEA, 2016).

In order to analyze the long-run relationship and short-run dynamic interactions between CO_2 emissions, GDP variables, energy use, exports and imports the autoregressive distributed lag (ARDL) cointegration technique developed by Pesaran et al., (2001), extended to introduce the structural break in the studied variables, has been used. This technique has the advantage of being able to be applied without having variables integrated of the same order, but integrated of order one I(1), order zero I(0) or fractionally integrated. The ARDL technique also allows unbiased estimates of the long-run model to be obtained (Harris and Sollis, 2003).

With a view to identifying a possible structural break for each variable included in this study, the breakpoint unit root test has been used. Nelson and Plosser (1982) stated that almost all macroeconomic variables have a unit root, and thereby the series shocks will continue in the long run. However, Perron (1989) advanced a new framework for which most macroeconomic time series do not possess the unit root, the fluctuations being transitory. Therefore, if the unit root test does not take into account the structural break point, the test will be biased. Zivot and Andrews (1992) developed a break point unit root test when the structural change is selected endogenously. The break point occurs when the t-statistic related to the unit root test is at its minimum value (Lee and Strazicich, 2001). Following Perron (1989) and Zivot and Andrews (1992), there are three types of break point, the first is related to changes in the level of the time series (change in the intercept), the second results from the change in the rate of growth (change in the trend), and the third is the result of both (change in the level and in the rate of growth).

According to Pesaran et al., (2001), the ARDL bounds testing approach may be implemented in three steps. The first step is to estimate Equation [1] by ordinary least squares, in order to test for the existence of a long-run relationship between the variables, by conducting an F-test for the joint significance of the coefficients of the lagged level variables, which indicates no cointegration relationship between them. Equation [1] may be written as follows:

$$DlogCO_{2,\mathrm{t}}=c+\propto_1 logCO_{2,\mathrm{t}-1}+\propto_2 logGDP_{\mathrm{t}-1}+\propto_3 (logGDP_{\mathrm{t}-1})^2+\propto_4 logE_{\mathrm{t}-1}+ \propto_5 logExp_{\mathrm{t}-1}+\propto_6 logImp_{\mathrm{t}-1}+\sum_{\mathrm{i}=1}^{\mathrm{P}}\beta_{1\mathrm{i}}DlogCO_{2,t-i}+\sum_{\mathrm{i}=0}^{\mathrm{P}}\beta_{2\mathrm{i}}DlogGDP_{\mathrm{t-i}}+ \sum_{\mathrm{i}=0}^{\mathrm{P}}\beta_{3\mathrm{i}}\mathrm{D}(logGDP_{\mathrm{t-i}})^2+\sum_{\mathrm{i}=0}^{\mathrm{P}}\beta_{4\mathrm{i}}DlogE_{\mathrm{t-i}}+\sum_{\mathrm{i}=0}^{\mathrm{P}}\beta_{5\mathrm{i}}DlogExp_{\mathrm{t-i}} + \sum_{\mathrm{i}=0}^{\mathrm{P}}\beta_{6\mathrm{i}}DlogImp_{\mathrm{t-i}}+ break_t+\gamma t+\varepsilon_{\mathrm{t}}. \qquad [1]$$

Where, *log* is the natural logarithm, *D* indicates the variable in the first difference, CO_2 is the variable referring to CO_2 emissions per capita, *GDP* the real gross domestic product per capita, *E* is the energy use per capita or alternatively the electricity consumption per capita, *Exp* is the exports of goods and services related to GDP, *Imp* is the imports of goods and services related to GDP, *break* is the dummy variable that captures the regime change in the model, *c* is an intercept, *t* refers to the time period in years from 1970 to 2010. Finally, ε_t is a white-noise error term.

The lag (P) is determined using the VAR optimal model, which means that the lag minimizes the Akaicke (AIC), Schwarz (SIC) and Hannan-Quinn (HIC) information criteria.

Once Equation [1] has been estimated, the presence of a cointegration relationship between the variables has to be studied by using the bounds test. Indeed, the cointegration test is based mainly on the Fisher test (F-stat) for the joint significance of the coefficients of the lagged level variables, i.e., H0: $\propto_1=\propto_2=\propto_3=\propto_4=\propto_5=\propto_6=0$, which indicates no cointegration, against the alternative H1: $\propto_1\neq\propto_2\neq\propto_3\neq\propto_4\neq\propto_5\neq\propto_6\neq0$ which indicates that there is integration. After comparing the F-stat value with asymptotic critical value bounds calculated by Pesaran et al., (2001), the null hypothesis of no cointegration is rejected when the value of the F-test exceeds the upper critical bounds value, implying that there is a cointegration relationship between the studied variables.

Once the null hypothesis of no cointegration is rejected, and cointegration is established, in the second step, the conditional ARDL long-run model that captures the long-run dynamic may be estimated as [2], where the orders of the ARDL(q1,q2, q3, q4,q5, q6) model are selected by using AIC.

$$logCO_{2,t}=c+\sum_{i=1}^{q1}\propto_{1i}logCO_{2,t-i}+\sum_{i=0}^{q2}\propto_{2i}logGDP_{t-i}+\sum_{i=0}^{q3}\propto_{3i}(logGDP_{t-i})^{2}+\sum_{i=0}^{q4}\propto_{4i}logE_{t-i}+\sum_{i=0}^{q5}\propto_{5i}logExp_{t-i}+\sum_{i=0}^{q6}\propto_{6i}logImp_{t-i}+break_{t}+\gamma t+\varepsilon_{t}. \quad [2]$$

Finally, the end step aims to estimate the error correction model for the short-run by using the ordinary least squares method and the AIC and SIC to select the order of the ARDL (p1, p2, p3, p4, p5, p6). This model may be written as follows:

$$DlogCO_{2,t}=c+\propto_{1}+\sum_{i=1}^{P1}\beta_{1i}DlogCO_{2,t-i}+\sum_{i=0}^{P2}\beta_{2i}DlogGDP_{t-i}+\sum_{i=0}^{P3}\beta_{3i}D(logGDP_{t-i})^{2}+\sum_{i=0}^{P4}\beta_{4i}DlogE_{t-i}+\sum_{i=0}^{P5}\beta_{5i}DlogExp_{t-i}+\sum_{i=0}^{P6}\beta_{6i}DlogImp_{t-i}+Dbreak_{t}+\gamma t+\mu ECM_{t-1}+\varepsilon_{t}. \quad [3]$$

In addition, the stability of the error correction model [eq.3] was checked by the Cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests.

4. Descriptive analysis of the used Data

Table 1 shows the main descriptive statistics of the variables used in this analysis: CO_2 emissions per capita, real GDP per capita, energy use per capita and alternatively electricity consumption per capita, and exports and imports of goods and services relate to GDP. Furthermore, on the basis of the break unit root test, the appropriate dummy variables which capture the regime changes are identified. All variables are referred to the period from 1970 to 2010.

[Insert Table 1]

CO_2 emissions per capita come from the World Bank database (2016a). The measure is metric tons per capita in logarithmic terms. The energy use and electricity consumption also come from the World Bank database (2016a). The energy use is measured as kg of oil equivalent per capita in logarithmic terms and refers to the use of primary energy before transformation to other end-use fuels. The electricity consumption is measured as kWh per capita in logarithmic terms. The exports and imports of goods and services came from the same database, and are measured as the percentage of GDP in logarithmic terms. GDP is measured as the real GDP per capita (PPP Converted) at 2005 constant prices obtained from the Penn World Table 7.1 (Heston et al., 2012).

Table 2 shows the correlation coefficients between the variables included in the study. A large positive correlation appears between CO_2 emissions and energy use and the real GDP, whereas its correlation with goods and services imports is small and negative. A large positive correlation also appears between CO_2 emissions and the electricity consumption. Additionally, Table 2 shows a strong positive correlation between the energy use and GDP, and electricity consumption and GDP.

[Insert Table 2]

The upper graph in Figure 1 shows that the evolution of CO_2 emissions per capita has experienced strong growth during the period from 1970 to 1980, with a notable annual growth rate, which may be related to the development plans adopted by the Algerian Government in this period. In that sense, according to De-Bernis (1971), the percentage of investment throughout the four-year plan (1970 - 1973) was 35% of GDP. During the 1970-1980 period, several gigantic factories were created, such as the El-Hadjar Steel Complex, which led to significant increases of energy consumption (the growth rates were 7.52% and 10.37% in the first and the second five-years of the decade of the 1970s, respectively), and therefore the CO_2

emissions grew. Since 1985, the emissions show a slightly negative trend until 2005, with a positive growth since then.

According to Sahnoune et al. (2013), Algeria is one of the important emitters among developing countries. The average annual global emission of CO_2 is 4.7 T / inhabitant, which is lower than Qatar with 55.4 T /inhabitant, and UAE with 31.1 T / inhabitant, but higher than Tunisia (2.4 T / inhabitant), Morocco (1.5 T / inhabitant) and India (1.4 T / inhabitant). By activity, the energy sector (production and consumption) is the source of highest emissions, about 75% of the total.

[Insert Figure 1]

The graph located at the bottom in Figure 1 shows the evolution of the real GDP per capita during the period 1970 to 2010. A growing trend can be observed until 1985, followed by a decreasing period until 1995 and a growing trend since then. According to Chemingui (2003), from 1962 to 1985 Algeria enjoyed its highest economic growth, led principally by the growth in the manufacturing sector which benefited from intensive public investment. During the period 1985 to 1995, Algeria passed firstly through a period of macroeconomic instability, resulting from the low oil prices per barrel on the international market, difficult adjustments and poor economic growth; and secondly, through the period of implementation of the first adjustment program, during which economic growth remained in decline. Finally, since 1995, Algeria resumed its growth improvement, which may be associated with the adoption of the second economic reform supported by the World Bank and the IMF, and the high oil price levels reached throughout the period from 2000.

5. Results and discussion

5.1. Breakpoint unit root test (selected structural point):

Table 3 reports the results of the endogenous break point unit root test, following the third type of break point (change in the level and in the rate of growth). The break years are selected when the t-statistic related to the ADF-test is at the minimum.

[Insert Table 3]

The results obtained from the break point unit root test on the studied variables bring out five structural breaks for the decade of the 1980s, when the Algerian economy experienced a substantial change. In this period, the Algerian economy knew the first economic reforms in 1982, the financial crisis resulting from the drastic fall of the oil price in the international market in 1986, and also the deep economic reforms started in 1988, which allowed Algeria to be transformed from a socialist economy to a market economy. Therefore, a dummy variable, called *break*, has been incorporated in the analysis to capture the structural change of the 1980s, taking the value one for the 1982 to 1989 years, and zero for all other years.

5.2. Unit root test (stationary test)

Adopting the ARDL bounds methodology requires certainty that all variables are not integrated two, I(2), or more times. Consequently, a test for the stationary status of the selected time series data to determine their order of integration has to be made. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) (1988) tests were conducted.

Table 4 shows the results of the unit root tests. None of the variables is I(2) according to both tests. Therefore, the ARDL technique is appropriate to estimate the possible cointegration relationship between the variables included in the econometric model.

[Insert Table 4]

5.3. ARDL bounds test

Table 5 shows the results of the ARDL bounds test for the cointegration relationship based on the equation [2]. The appropriate lag lengths P=2 (when using energy use) and P=4 (when using electricity consumption) were selected on the basis of the selection criteria (Akaike criterion, final prediction error and information criterion and the Hannan-Quinn information criterion).

According to the bounds test developed by Pesaran et al., (2001), the test of cointegration relationship is related to the estimate of equation [1]. The value of F-stat is calculated by taking into account the null hypothesis where the parameters estimated with respect to the variables at the level equal to zero. If the calculated value of F-stat surpasses the hyper appropriate critical values of the bounds test, the null hypothesis of no cointegration is rejected, and therefore, there is a cointegration relationship between the studied variables. Table 5 shows that the values of F-Stat (when using energy use and electricity consumption) surpass the upper value of bounds test whether at 1% or at 5%. Therefore, there is a cointegration relationship between the CO_2 emissions, real GDP, real GDP squared, energy use, imports of goods and services and exports of goods and services; and also, there is a cointegration relationship between the CO_2 emissions, real GDP, real GDP squared, electricity consumption, imports of goods and services and exports of goods and services

[Insert Table 5]

5.4. Estimating the long-run dynamic and the short-run dynamic with break point

On the basis of equation [2] and equation [3], the ordinary least squares method was employed to obtain the estimated parameters of the long-run and the short-run relationships.

The obtained results when using energy use as an energy variable are reported in Table 6, while when using electricity consumption are reported in Table 7.

[Insert Table 6 and Table 7]

Column 2 in Table 6 and in Table 7 show the results of estimating [2] by using the ordinary least squares method. AIC and SIC are used to select the optimum number of lags in the ARDL model. The Breusch Godfrey test (LM-test) indicates that the null hypothesis of presence of serial correlation in the residuals is rejected in both estimates at 5%. Column 4 in Table 6 and in Table 7 show the results of estimating [3]. The optimal estimated error correction model associated with the long-run relationship was also found in the basis of AIC and SICS criteria. The estimated error correction coefficient ECM(-1) is negative and significant at 1% for both estimates (when using energy use or electricity consumption). Its value, higher than 0.92 (0.97 when using electricity consumption), indicates that the adjustment speed to restore long-run equilibrium in the dynamic model will be corrected by 92% (97% when using electricity consumption) for in one year. Additionally, Figure 2 shows the plots of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum squares of recursive residuals (CUSUMSQ) tests for both estimates. Graphs in Figures 2 and 3 show that the coefficients of the error correction model are stable during the studied period as they are within the critical bounds of 5%.

[Insert Figure 2 and 3]

Table 6 and Table 7 show that the elasticity with respect to real GDP per capita is positive and statistically significant in the long-run and short-run relationships, their values being 2.44 and 1.73 respectively (1.8 and 1.47 when using electricity consumption). Moreover, the estimated coefficient related to the real GDP per capita squared appears negative and significant for both specifications. Therefore, the EKC hypothesis is confirmed. These results are in line with the reported results for African countries in Narayan and Narayan (2010). In that study, the authors conclude that Ghana, South Africa, Algeria, Ethiopia, Kenya, Nigeria, and Congo were the countries in the African region for which the EKC is supported. Likewise, Arouri et al. (2012) found an EKC for Algeria over the period 1981–2005.

Results in Table 6 also show that the estimated coefficients for energy use are positive when estimating [3] (short run estimate), and when estimating [2] and the energy use variable is delayed two periods. Results in Table 7 also show that estimated coefficients for the electricity variable are positive. Both results indicate that an increase in energy use or electricity consumption in per capita terms increase CO_2 emissions. In this regard, results are in line with previous studies indicating that energy consumption has a positive impact on CO_2 emissions in MENA countries, as for example in Arouri et al. (2012). Likewise, results are also in line with findings by Farhani and Shahbaz (2014) for a panel of ten MENA countries including Algeria. Therefore, energy use and electricity consumption add to CO_2 emissions. No major differences are observed by using energy use or electricity consumption, which may be due to the fact that 97.5% of the electricity is generated from fossil fuel.

Additionally, the results also show that export coefficients are negative and statistically significant in the long-run and short-run relationships (for both Table 6 and Table 7), while import coefficients are positive and statistically significant (except in the short-run relationships for non-delayed variables, in which cases the estimated coefficients are not statistically significant). The different sign of these coefficients confirms the appropriateness of treating both variables independently, instead of considering trade openness.

Furthermore, the dummy variable related to the regime change of the Algerian economy experienced in the 1980s appears negative and significant in the long-run and short-run relationships in both Tables.

5.5. Discussion

The obtained results presented in Tables 6 and 7 confirm the EKC for Algeria. Therefore, it may be concluded that emissions will decrease from a threshold level of income. Thus the Algerian policymakers may promote their economic growth and just wait to comply with their INDC targets. Nevertheless, several questions may be taken into account by the Algerian policymakers before opting for the just wait approach.

Firstly, the threshold level of income from which the emissions are expected to decrease may be very high. According to Dinda (2004), the turning point (for logarithmic value) may be calculated as the relation of GDP coefficient to 2*GDP^2 this value being from estimated results as 2.44/2*0.1= 12.2 or alternatively as 1.8/2*0.09 =10. However, the maximum value of per capita real GDP in logarithmic terms has been 8.74 during the analyzed period. This means that the turning point is reached for a 252.5% higher value of per capita real GDP than has already been reached (for a log value equal to 10). These results, which are in line with the findings of Arouri et al. (2012), indicate that economic growth in Algeria will continue to increase emissions. Therefore, some energy policies may be taken to comply with the INDC (2015) targets without affecting the economic growth.

Secondly, the EKC in Algeria may be related to the slow growth of the Algerian economy and the structure of its economy. During the analyzed period, the annual mean growth rate of real GDP per capita achieved in Algeria was 1.09% (World Bank, 2016a). Therefore, the EKC in Algeria may be related to the fact of an initial development, in line with the results of Ozcan (2013) and Wang et al. (2011), who considered that pollution levels may decrease as a country develops when income levels are low, but may increase as the income levels are higher.

In that sense, and as stated in Brenton et al. (2006) and Bouznit et al. (2015), some reasons may be behind the Algerian slow growth. Algeria had a modest investment in the manufacturing sector (CIA World Factbook, 2015) and a rapid deindustrialization, characterizing the period from 1980 to the present, which led to a rapid decrease in the share of manufacturing in Gross Value Added, from 17% in 1970 to less than 5% in 2010. All attempts at industrial reforms have not begun to show any signs of improvement in their performance until 2013 (Beggar and Merghit, 2014). Therefore, the economic growth has not been related to industrialization in Algeria. It may be highlighted that the industrial processes are highly energy intensive, accounting for one-third of global energy use and 40% of total CO_2 emissions worldwide (Brown et al, 2012). Therefore, the limited industrialization of Algeria has implied less energy requirement and therefore lower emissions. Greater industrialization of Algeria, as recommended by international organizations, will mean greater energy needs, generating more emissions, since according to Column 2 in Table 6, CO_2 emissions per capita with respect to energy use is positive and statistically significant. In fact, the energy needs grew 3.7% for the industrial sector in 2013 (IEA, 2016).

Additionally, Algeria's economy is based primarily on the exports of gross fuel and oil products, which represented more than 97% of goods and services exports in 2010. The extraction of these natural resources provokes high emissions. Nevertheless, most of these exports, according to IEA (2016), are crude oil and natural gas (82%), with only 18% of energy exports related to oil products, which are the most contaminating. The deindustrialization process leant Algeria heavily towards gross fuel exports in order to satisfy the needs of its population, by increasing fuel extraction on the one hand, and by diminishing the use of energy previously reserved for the industrial sector on the other. Therefore, the significant trend of increasing exports of gross fuels in Algeria, instead of oil products and manufacturing, may explain the negative sign of the estimated coefficient of exports in the long-run and short-run. Additionally, Table 6 shows positive and significant coefficients for imports variables. As stated in Guechari (2012), Algeria's imports are mainly composed of raw materials which tend to meet the needs of the industrial sector, and huge quantities of diesel and gasoline are designed to meet the fuel demand for vehicles and agriculture. Thus, despite Algeria being specialized in gross oil exports, diesel and gasoline are imported to the amount of more than 3.4 billion dollars, producing emissions.

Thirdly, it is worth noting that the total final energy consumption of the country has seen an increase of 22% from 2010 to 2013, which may be related specially to changes in the way of life, as the main increases are related to the residential sector and electricity consumption (IEA, 2016). Moreover, electricity demand is expected to more than double by 2030 (Nachmany et al., 2015). Therefore, increasing emissions may be expected if no changes are applied in the energy mix, as the coefficient for electricity consumption is positive.

Consequently, if the Algerian government wants to comply with the INDC target and not negatively affect economic growth, some energy policies should be implemented in order to take into account the possible negative effects of an industrialization process, greater economic growth and growing energy needs. With this aim, Algeria should use renewable energies and environmentally friendly energy conversion technologies. Along that line, the Algerian government approved the Renewable Energy and Energy Efficiency National Plan 2011-2030 (Algerian Ministry of Energy and Mines, 2011) and recently the National Climate Plan 2013 (Algerian Ministry of Energy and Mines, 2013), which has confirmed the Algerian political commitment to the exploitation of renewable energy. Thus, 22,000 MW of power generating capacity shall be installed from renewable sources between 2011 and 2030. Additionally, this plan also pays great attention to the important role of energy efficiency by improving heat insulation of buildings, spreading the use of low energy consumption lamps, promoting co-generation, converting simple cycle power plants to combined cycle power plants and promoting liquefied petroleum and natural gas fuels. Nevertheless, this document does not include specific measures to comply with these objectives.

In accordance with Boughali (2014), to promote this development of renewable energy, reduce energy use and promote energy efficiency, it is mandatory to develop a specific sustainable energy model and identify the different possible energy scenarios depending on the national and global energy contexts. Once this model is defined, some measures to promote renewable energies and energy efficiency should be considered with the aim of stimulating new renewable installations. Some measures are already being applied, such as feed-in tariffs, but there is still much work to do. For example, internal tax benefits for renewable energy projects or fiscal incentives to encourage energy efficiency investments are not applied (RCREEE, 2012a, 2012b, 2015). Additionally, with the aim of promoting economic growth without generating high emissions, Algeria should also include energy policies for reducing electricity distribution and transmission losses. In this area, the energy savings may be great as the losses are estimated at 20% (Belaid and Abderrahmani, 2013).

Several problems may hinder the adequate attainment of the targets set in this plan. Firstly, the drop in oil prices since mid-2014 is having a negative impact on the Algerian current account. The earnings from hydrocarbons exports have dropped by around 50% in 2015, making their imports exceed their exports for the first time in 15 years (IMF, 2014). Thus, the Algeria government will have more difficulty in financing investments and subsides to promote renewable energy and energy efficiency. Therefore, attracting foreign investors may be necessary. Nevertheless, Algeria has experienced difficulties in attracting foreign investments for energy investments in the past. As stated in the EIA (2016) report, the lack of fiscal incentives to attract foreign investors to new projects, opaque regulations, corruption allegations and a precarious security environment, have been of concern to investors. In that sense, Algeria’s business environment, ranked 163rd out of 189 countries in the report *Doing Business 2016* (World Bank, 2016b), has been constraining investment in the energy sector in recent years. Therefore, some more regulatory reform is needed in order to facilitate bureaucratic processes and improve transparency. In addition, it may be appropriate to advance the study of the effect of the application of promotional measures on foreign investment and the reduction of CO_2 emissions in Algeria.

Secondly, the energy demand growth, and especially residential energy demand growth has raised domestic gas consumption. Nevertheless, the domestic gas consumption has risen faster than production. Therefore, the gas reserved for exports tends to decrease, diminishing export revenues. In order to manage the domestic consumption without compromising exports, the government has attempted to increase natural gas output and crude oil production (EIA, 2016). As these new plants may increase CO_2 emissions, it may be appropriate to find mechanisms to control these emissions, such as continuing to store the CO_2 removed during gas extraction, by pumping it into an aquifer below the gas reservoir (Layachi, 2013). In this sense, as stated in Ang and Su (2016), the possibility of employing these carbon capture and storage technologies in a large scale in electricity production could greatly reduce the carbon intensity for electricity.

Additionally, it may be appropriate to promote some energy policies to control energy demand. For this, energy efficiency measures are crucial, as renewable energy production, according to Paroussos et al. (2012), does not seem to be enough to cover all the increased electricity demand. Along that line, it may be appropriate to decrease subsides in energy prices. Algeria has been maintaining tight control of domestic energy prices, as in many Arabic countries. Nevertheless, energy subsidies distort price signals, with negative implications on efficiency by favoring the development of energy-intensive industries and inducing large inefficiencies into the way in which energy is consumed (Fattouh and El-Katiri, 2012). According to the *Loi de finances 2016,* the Algerian energy regulator has recently increased electricity and gas tariffs for high-voltage electricity and high pressure gas (industry) by 20% and 35% respectively. However, no price increase has been applied for low-voltage electricity which satisfies the electricity needs for households. Therefore, it may be appropriate to continue with this policy of reducing energy prices, although it may also be necessary to apply some effective compensatory schemes, such as protecting low income groups and the domestic demand base for industries and businesses.

6. Conclusions and policy implications

The Algerian authorities have begun to be conscientious regarding their environmental problems. Algeria has been one of the countries with a special interest in signing the COP21 agreement, being one of the first developing countries to send their INDC. The Algerian INDC pledged to curb carbon emissions by at least 7%, compared to business-as-usual levels by 2030. However, complying with this target may be a difficult task, without compromising economic growth and the increase of the standard of living for their inhabitants.

This paper analyzes the relationship between CO_2 emissions and economic growth in Algeria, taking into account the energy use, exports and imports. With this objective, the validity of the EKC hypothesis throughout the period from 1970 to 2010 has been tested. The methodology adopted is the application of the ARDL model extended to introduce the break points. The results of this analysis allow enlarging the EKC literature for African countries.

The estimated results show that the elasticity, with respect to real GDP per capita, is positive and significant in the long and the short run, with that related to the real GDP per capita being negative and significant. The results also show that the estimated coefficients for energy use and electricity consumption are both positive and significant, indicating that an increase in energy use and electricity consumption in per capita terms increases CO_2 emissions. Additionally, the results show that export coefficients are negative while import coefficients are positive and statistically significant. The different sign of these coefficients confirms the appropriateness of treating both variables independently, instead of considering trade openness.

These results confirm the EKC for Algeria. Nevertheless, the turning point is reached for a 252.5% higher value of per capita real GDP than has already been reached, which indicates that economic growth in Algeria will continue to increase emissions.

Algeria had a modest investment in the manufacturing sector and a rapid deindustrialization characterizing the period from 1980 to the present. This limited industrialization of Algeria has implied less energy requirement and therefore lower emissions. Consequently, greater industrialization to promote growth in Algeria, as recommended by international organizations, will mean greater emissions. Additionally, the total final energy consumption of the country has seen an increase of 22% from 2010 to 2013, with the main increase being related to the residential sector and electricity consumption. Therefore, increasing emissions may be expected if no changes are applied in the energy mix, as the coefficient for energy use and electricity consumption are positive.

Some energy policies may be taken to comply with the INDC (2015) targets without affecting the economic growth, in order to take into account the possible negative effects of an industrialization process, greater economic growth and growing energy needs. With this aim, Algeria should use renewable energies and environmentally friendly energy conversion technologies. Along that line, the Algerian government recently approved the National Climate Plan committing to the exploitation of renewable energy and to the improvement of energy efficiency. However, this document does not include specific measures to comply with these objectives. Therefore, it is appropriate to develop a specific sustainable energy model identifying different possible energy scenarios and to consider specific measures to promote these renewable energies and energy efficiency. Tax benefits for renewable energy projects or fiscal incentives to encourage energy efficiency investments may be recommended.

Nevertheless, several problems may hinder the adequate attainment of the targets set in this plan. Firstly, the drop in oil prices, which is having a negative impact on the Algerian current account, will make financial investments and subsides to promote renewables and energy efficiency more difficult. Thus, attracting foreign investors may be necessary. However, some obstacles are hindering these investments, such as lack of fiscal incentives, opaque regulations, corruption allegations and a precarious security environment. Therefore, regulatory reforms are needed to facilitate bureaucratic processes and to improve transparency.

Secondly, the energy demand growth has raised domestic gas consumption. Consequently, the government has attempted to increase natural gas and crude oil output, by adding new plants to preserve fuel exports, which ultimately means more emissions. Therefore, measures such as continuing the storage of the CO_2 removed during gas extraction are recommended. Likewise, energy policies to control energy demand are recommended. In that sense, energy efficiency measures seem to be crucial. Moreover, it may be appropriate to decrease subsides in energy prices to encourage energy efficiency, applying, at times, some effective compensatory schemes for negative price rise effects.

In this sense, further research on the drivers of energy consumption in Algeria and on the effect of rising energy prices on reducing emissions and on their social costs, may be appropriate to perform in future.

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References

Akbostanci, E., Turut-Asik, S., Ipek, T. G. 2009.The relationship between income and environment in turkey: Is there an environmental Kuznets curve? Energy Policy. 37, 861-867.

Alam, M. J., Begum, I. A., Buysse, J., Van Huylenbroeck, G. 2012. Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. Energy Policy, 45, 217-225.

Algerian Ministry of Energy and Mines. 2011. *Renewable Energy and Energy Efficiency Program*. Algerian Ministry of Energy and Mines

Algerian Ministry of Energy and Mines. 2013. *National Climate Plan 2013.* Algerian Ministry of Energy and Mines.

Al-Mulali, U., Saboori, B., Ozturk, I. 2015. Investigating the environmental Kuznets curve hypothesis in Vietnam.Energy Policy. 76, 123-131.

Al-Mulali, U., Solarin, S. A., Ozturk, I. 2016. Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: an autoregressive distributed lag (ARDL) approach. Natural Hazards, 80(3), 1729-1747.

Ang, J.B., 2007. CO_2 emissions, energy consumption, and output in France. Energy Policy. 35, 4772–4778.

Ang, B.W., Su, B. 2016. Carbon emission intensity in electricity production: A global analysis. Energy Policy, 94, 56–63

Arouri, M. E. H., Youssef, A. B., M'henni, H., Rault, C. 2012. Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries. Energy Policy. 45, 342-349.

Apergis, N., Payne, J. E. 2009. CO 2 emissions, energy usage, and output in Central America. Energy Policy, 37(8), 3282-3286.

Begga, C., Merghit, M., 2014. Attempts to industrial reforms in Algeria: Do they fit the logic of globalization? Topics in Middle Eastern and African Economies. 16 (1).

Belaid, F. and Abderrahmani, F. 2013. Electricity consumption and economic growth in Algeria: A multivariate causality analysis in the presence of structural change. Energy Policy, (55), 286- 295.

Bento, J. P. C., Moutinho, V. 2016. CO 2 emissions, non-renewable and renewable electricity production, economic growth, and international trade in Italy. Renewable and Sustainable Energy Reviews, 55, 142-155.

Boughali, S., Bechki, D., Mennouche, D., Mahcene, H., Bouguettaia, H., Bouchekima, B. 2014.Opportunites et challenges de la promotion des énergies renouvelables en Algerie. Annales des Sciences et Technologie, 5(1), 53-62.

Bouznit, M. Ferfera, M.Y., Pablo-Romero, M.P. 2015. The Slow Economic Growth in Algeria. A Comparative Study with Respect to South Korea. African Development Review. 27 (4), 377-391.

Brander, M., Sood, A., Wylie, C., Haughton, A., Lovell, J. 2011. Electricity-specific emission factors for grid electricity. Ecometrica. *Edinburgh, United Kingdom*.

Brenton, P., Baroncelli, E., Malouche, M. 2006.Trade and investment integration of the Maghreb.World Bank.

Brown, T., Gambhir, A., Florin, N., Fennell, P. 2012.Reducing CO_2 emissions from heavy industry: a review of technologies and considerations for policy makers. Grantham Institute for Climate Change paper N° 7.

Chemingui, M. A. 2003. What macroeconomics factors explain Algeria’s poor economic growth performance. Kuwaiti Institute for Scientific Research.

CIA World Factbook.2015.Algeria Economy 2015.Fromhttps://www.cia.gov/library/publications/the-world-factbook/geos/ag.html

Cowan, W. N., Chang, T., Inglesi-Lotz, R., Gupta, R. 2014. The nexus of electricity consumption, economic growth and CO 2 emissions in the BRICS countries. Energy Policy, 66, 359-368.

Damette, O., Seghir, M. 2013. Energy as a driver of growth in oil exporting countries?. Energy Economics, 37, 193-199.

De-Bernis, G. D., 1971. Les industries industrialisantes et les options algériennes. Tiers-Monde en l’an 2000. N°.47, 545-563.

Dinda, S. 2004. Environmental Kuznets curve hypothesis: a survey. Ecological economics, 49(4), 431-455.

EIA. 2016. *Country Analysis Brief: Algeria*. Washington, DC: U.S. Energy Information Administration.

Fattouh, B., El-Katiri, L. 2012. *Energy subsidies in the Arab world*. New York : United Nations Development Programme

Farhani, S., Chaibi, A., Rault, C. 2014b. CO_2 emissions, output, energy consumption, and trade in Tunisia. Economic Modelling. 38, 426–434.

Farhani, S., Mrizak, S., Chaibi, A., Rault, C. 2014a. The environmental Kuznets curve and sustainability: A panel data analysis. Energy Policy, 71, 189-198.

Farhani, S., Shahbaz, M. 2014. What role of renewable and non-renewable electricity consumption and output is needed to initially mitigate CO 2 emissions in MENA region?. Renewable and Sustainable Energy Reviews, 40, 80-90.

Fodha, M., O. Zaghdoud, O. 2010. Economic growth and environmental degradation in Tunisia: An empirical analysis of the environmental Kuznets curve. Energy Policy. 38, 1150–1156.

Grossman, G. M. Krueger, A. B. 1991. Environmental impacts of a North American Free Trade Agreement. National Bureau of Economic Research, Working Paper 3914, NBER, Cambridge MA.

Guechari, Y. 2012. An empirical study on the effects of real effective exchange rate on Algeria’s trade balance. International Journal of Financial Research. 3 (4), 102-115.

Halicioglu, F. 2009.An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy. 37, 1156–1164.

Harris, R., Sollis, R. 2003. Applied Time Series Modelling and Forecasting, Chichester, England, UK.

Heston, A., Summers, R., Bettina, A. 2012. Penn World Table Version 7.1. Centre for International Comparisons of Production, Income and Prices at the University of Pennsylvania.

INDC. 2015. *Intended Nationally Determined ContributionINDC-Algeria.* UNFCCC

International Monetary Fund IMF. 2014. *Algeria Selected Issues* IMF Country Report No. 14/34:Washington, D.C

International Energy Agency- IEA-. 2016 .Energy Balances Database. IEA: Paris

Iwata, H., Okada, K., Samreth, S. 2010. Empirical study on the environmental Kuznets curve for CO 2 in France: the role of nuclear energy. Energy Policy, 38(8), 4057-4063.

Jalil, A., Feridun, M. 2011.The impact of growth, energy and financial development on the environment in China: Acointegration analysis. Energy Economics.33, 284-291.

Kaika, D., Zervas, E. 2013. The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO 2 emissions case. Energy Policy, 62, 1392-1402.

Kasman, A., Duman, Y. S. 2015. CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis. Economic Modelling, 44, 97-103.

Kijima, M.,Nishide, K., Ohyama, A. 2010.Economic models for the environmental Kuznets curve: Asurvey. Journalof Economic Dynamics and Control. 34, 1187-1201.

Kohler, M. 2013. CO 2 emissions, energy consumption, income and foreign trade: a South African perspective. Energy Policy, 63, 1042-1050.

Koirala, B. S., Li, H., Berrens, R. P. 2011. Further investigation of environmental Kuznets curve studies using meta-analysis. International Journal of Ecological Economics and Statistics. *22* (S11), 13-32.

Kivyiro, P., Arminen, H. 2014. Carbon dioxide emissions, energy consumption, economic growth, and foreign direct investment: Causality analysis for Sub-Saharan Africa. Energy, 74, 595-606.

Lacheheb, M., Rahim, A.S.A., Sirag, A. 2015. Economic growth and CO2 emissions: Investigating the Environmental Kuznets Curve hypothesis in Algeria. International Journal of Energy Economics and Policy, 5(4), 1125-1132.

Layachi, A. 2013. *The Changing Geopoltics of Natural Gas: The Case of Algeria*. James A. Baker III Institute for Public Policy Rice University.

Lee, J., Strazicich, M. C. 2001. Break point estimation and spurious rejections with endogenous unit root test. Oxford Bulletin of Economics and Statistics. 63 (5), 535-558.

Li, T., Wang, Y., Zhao, D. 2016. Environmental Kuznets curve in China : New evidence from dynamic panel data. Energy Policy. 91, 138-147.

Lotfalipour, M. R., Falahi, M. A., Ashena, M. 2010. Economic growth, CO 2 emissions, and fossil fuels consumption in Iran. Energy, 35(12), 5115-5120.

M'henni, H. 2005. Economic development, adjustment and environmental quality: the case of Tunisia for a contingent valuation study. Mediterranean Journal of Economics, Agriculture and Environment. IV (2), 36-42.

Nachmany, M., Fankhauser, S., Davidová, J., Kingsmill, N., Landesman, T., Roppongi, H., Schleifer, P., Setzer, J., Sharman, A., Singleton, C.S., Sundaresan J., Townshend, T. 2015. *The GLOBE climate legislation study: a review of climate change legislation in 99 countries*. The Grantham Research Institute on Climate Change and the Environment : London

Narayan, P.K., Narayan. S. 2010. Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. Energy Policy. 38 (1), 661–666.

Nasr, A. B., Gupta, R., Sato, J. R. 2015. Is there an Environmental Kuznets Curve for South Africa? A co-summability approach using a century of data. Energy Economics, *52*, 136-141.

Nelson, C. R., Plosser, C. I. 1982.Trends and random walks in macroeconomic time series.Journal of Monetary Economics. 10, 139-162.

Olivier, J.G.J., Janssens-Maenhout, G., Muntean, M. Peters, J. 2015. *Trends in global CO2 emissions: 2015 Report* PBL Netherlands Environmental Assessment Agency PBL, 1803.

Omri, A. 2013. CO 2 emissions, energy consumption and economic growth nexus in MENA countries: evidence from simultaneous equations models. Energy economics, 40, 657-664.

Onafowora, O. A., Owoye, O. 2014. Bounds testing approach to analysis of the environment Kuznets curve hypothesis. Energy Economics, 44, 47-62.

Osabuohien, E. S., Efobi, U. R., Gitau, C. M. W. 2014. Beyond the environmental Kuznets curve in Africa: Evidence from panel cointegration. Journal of Environmental Policy & Planning, 16(4), 517-538.

Oshin, S., Ogundipe, A. A. 2014. An Empirical Examination of Environmental Kuznets Curve (EKC) in West Africa. Euro-Asia Journal of Economics and Finance, 3(1).

Ozcan, B. 2013.The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: A panel data analysis. Energy Policy. 62, 1138–1147

Ozturk, I., Acaravci, A. 2010. CO 2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.

Ozturk, I., Acaravci. 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics. 36, 262-267.

Panayotou, T. 1993. Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working Paper WP238, Technology and Employment Programme. Geneva: International Labour Office

Pao, H. T., Tsai, C. M. 2011. Modeling and forecasting the CO 2 emissions, energy consumption, and economic growth in Brazil. Energy, 36(5), 2450-2458.

Paroussos, L., Fragkiadakis, K., Charalampidis, I., Tsani, S., Capros, P. 2013. *Quantitative Reference Scenario for the MEDPRO*. Project MEDPRO Report No. 6. European Commission.

Perron, P. 1989. The great crash, the oil price shock, and the unit root hypothesis. Econmetrica, 57 (6), 1361- 1401.

Pesaran, M. H., Shin, Y., Smith, R. J. 2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics.16, 289-326.

Phillips, P.C.B., Perron, P. 1988. Testing for a unit root in time series regression.Biometrika.75 (2), 335-346.

RCREEE. 2012a. *Renewable Energy Profile*. Cairo: Regional Center for Renewable Energy and Energy Efficiency

RCREEE. 2012b. *Energy Efficiency Profile*. Cairo: Regional Center for Renewable Energy and Energy Efficiency

RCREEE. 2015. *Arab Future Energy Index. Energy Efficiency 2015*. Cairo: Regional Center for Renewable Energy and Energy Efficiency

Sahnoune, F., Belhamel, M., Zelmat, M., Kerbachi, R., 2013. Climate change in Algeria: Vulnerability and strategy of mitigation and adaptation. Energy Procedia, 36, 1286-1294.

Shafik, N., Bandyopadhyay, S. 1992. Economic growth and environmental quality: Time series and cross-country evidence. Background Paper for the World Development Report 1992, the World Bank, Washington DC.

Shahbaz, M., Khraief, N., Uddin, G.S., Ozturk, I. 2014. Environmental Kuznets curve in an open economy: A bounds testing and causality analysis for Tunisia. Renewable and Sustainable Energy Reviews. 34, 325–336.

Shahbaz, M., Solarin, S. A., Mahmood, H., Arouri, M. 2013b. Does financial development reduce CO_2 emissions in Malaysian economy? A time series analysis. Economic Modelling, 35, 145-152.

Shahbaz, M., Solarin, S. A., Sbia, R., Bibi, S. 2015. Does energy intensity contribute to CO 2 emissions? A trivariate analysis in selected African countries. Ecological indicators, 50, 215-224.

Shahbaz, M., Tiwari, A. K., Nasir, M. 2013a. The effects of financial development, economic growth, coal consumption and trade openness on CO 2 emissions in South Africa. Energy Policy, 61, 1452-1459.

Soytas, U., Sari, R. 2009. Energy consumption, economic growth, and carbon emissions: challenges faced by an EU candidate member. Ecology Economics, 68, 1667-1675.

Stern, D. I. 2014.Kuznets curve (environmental).The Essential Guide to Global Environmental Governance, 109.

Tiwari, A. K., Shahbaz, M., Hye, Q. M. A. 2013. The environmental Kuznets curve and the role of coal consumption in India: cointegration and causality analysis in an open economy. Renewable and Sustainable Energy Reviews, 18, 519-527.

Tutulmaz, O. 2015. Environmental Kuznets Curve time series application for Turkey: Why controversial results exist for similar models? Renewable and Sustainable Energy Reviews, 50, 73-81.

Wang, S.S. Zhou, D.Q., Zhou, P., Wang, Q.W., 2011. CO_2 emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy. 39, 4870–4875.

World Bank. 2016a. Country Classification. Algeria.

https://datahelpdesk.worldbank.org/knowledgebase/topics/19280-country-classification

World Bank. 2016b. *Doing Business 2016. Measuring Regulatory Quality and Efficiency*. Washington DC: World Bank.

Zhang, X. P., Cheng, X. M. 2009. Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, 68(10), 2706-2712.

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.

Table 1: Descriptive statistics

Variables	Description	Mean	Max	Min	Std. Dev.	Obs
$logCO_2$	Per capita CO_2 emissions	0.99	1.24	0.02	0.26	41
logENU	Energy use (kg of oil equivalent per capita)	6.51	7.02	5.43	0.44	41
LogElec	Per capita electric consumption	6.09	6.89	4.88	0.57	41
logEXP	Exports as percentage to GDP	3.35	3.88	2.55	0.32	41
logIMP	Imports as percentage to GDP	3.30	3.76	2.91	0.19	41
log GDP	Per capita real GDP ($I constant)	8.50	8.74	8.14	0.13	41

Source: established by the authors

Table 2: The correlation matrix

	$logCO_2$	logENU	logExp	logImp	logGDP
$logCO_2$	1	0.79	0.06	-0.30	0.66
logENU	0.79	1	0.23	-0.51	0.84
logEXP	0.06	0.23	1	0.20	0.42
logIMP	-0.30	-0.51	0.20	1	-0.29
logGDP	0.66	0.84	0.42	-0.29	1
	$logCO_2$	logElec	logExp	logImp	logGDP
$logCO_2$	1	0.74	0.06	-0.30	0.66
logElec	0.74	1	0.37	-0.49	0.86
logEXP	0.06	0.37	1	0.20	0.42
logImp	-0.30	-0.49	0.20	1	-0.29
logGDP	0.66	0.86	0.42	-0.29	1

Source: established by the authors

Table 3. Endogenous break point unit root test on the studied variables

Variable	Break date	ADF-test	
		t-stat	Result
$logCO_2$	1982	-5.29**	I(0) with break point
logGDP	1987	-5.18**	I(0) with break point
$(logGDP)^2$	1987	5.17**	I(0) with break point

logENU	1977	-5.14**	I(0) with break point
logElec	2000	-4,38	not stationary
logImp	1985	-3,68	not stationary
logEXP	1985	-7.25***	I(0) with break point

I(0) denotes the variable is stationary at the level, while I(1) denotes the variable is stationary after the first difference.* ,** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table.4: results of unit root test on the log levels and the first difference of variables

Unit Root Test	ADF test	PP test	Result
	t-stat	t-stat	
Variables at level			
logCO$_2$	-4.54***	-4.42***	I(0)
logGDP	-2.01	1.51	Non-stationary
(logGDP)^2	-1.93	1.52	Non-stationay
logENU	-3.46***	-3.59***	I(0)
logElec	-3.44**	-2.81*	I(0)
logIMP	-2.21	-2.17	Non-stationary
logEXP	-2.33	-2.01	Non-stationary
Variables at first difference			
DlogGDP	-5.25***	-7.98***	I(1)
(logGDP)^2	-5.17***	-7.86***	I(1)
DlogIMP	-5.80***	-5.87***	I(1)
DlogEXP	-4.84***	-5.67***	I(1)

I(0) denotes the variable is stationary at the level, while I(1) denotes the variable is stationary after the first difference.* ,** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5: Bounds test of cointegration comparing to F-Stat

Energy use as energy variable

F-Stat	Bounds test at 1%^{a}		Bounds test at 5%^{a}	
	I(0)	I(1)	I(0)	I(1)
15.20	3.41	4.68	2.62	3.78

Electricity consumption as energy variable

F-Stat	Bounds test at 1%^{a}		Bounds test at 5%^{a}	
	I(0)	I(1)	I(0)	I(1)
5.02	3.41	4.68	2.62	3.78

[a] *The values of the bounds test have come from the table CI(iii) established by Pesaran et al., (2001)*

Table 6. The estimates of the ARDL model and error correction model with breakpoint. Energy use as energy variable

Long run relationship: estimating the eq.[2]		Short run relationship: estimating the eq.[3]	
Dependent Variable: Log CO$_2$		Dependent variable: Dlog CO$_2$	
ARDL(4,1,2,2,3,2)		ECM-ARDL(3,1,2,2,3,2)	
[1]	[2]	[3]	[4]
Variables	Coefficients	Variables	Coefficients
C	-13.44***	Dlog CO$_2$(-1)	-0.22**
	(2.89)		(0.093)
logCO$_2$(-1)	-0.24*	DlogCO$_2$(-3)	-0.10
	(0.139)		(0.079)
logCO$_2$(-2)	-0.09	Dlog GDP(-1)	1.73***
	(0.130)		(0.517)
LogCO$_2$(-4)	-0.09	D(logGDP(-2))^2	-0.09***
	(0.112)		(0.030)
log GDP(-1)	2.44***	DlogENU	-0.0004
	(0.580)		(0.0003)
(logGDP(-2))^2	-0.10***	DlogENU(-1)	0.0006*
	(0.034)		(0.0003)
logENU	-0.42	DlogENU(-2)	0.45**
	(0.274)		(0.192)
logENU(-2)	0.63***	DlogIMP(-1)	0.16
	(0.235)		(0.118)
logIMP	0.22*	DlogIMP(-2)	-0.17
	(0.121)		(0.109)
logIMP(-3)	0.52***	Dlog IMP(-3)	0.65***
	(0.141)		(0.114)
logEXP	-0.39***	DlogEXP	-0.39***
	(0.084)		(0.071)
logEXP(-2)	-0.24***	DlogEXP(-2)	-0.27***
	(0.095)		(0.072)
Break	-0.12**	EMC(-1)	-0.92***
	(0.061)		(0.230)
t	0.01*	DBreak	-0.24***
	(0.005)		(0.066)
Akaike info criterion	-1.92	Akaike info criterion	-2.20
Schwarz criterion	-1.31	Schwarz criterion	-1.59
LM-test	0.77	LM-test	2.21
Prob(LM-test)	0.67	Prob(LM-test)	0.33
ARCH-test	1.08	ARCH-test	1.74
Prob(ARCH)	0.29	Prob(ARCH)	0.18
Normality tesst (JB)	0.36	Normality tesst (JB)	0.85
Prob(JB)	0.83	Prob(JB)	0.65

*Note: Standard errors in brackets. ***, **, * denotes significance at 1%, 5% and at 10% respectively. Also, the AIC and SC are used to select the optimum number of lags in the ARDL model and the error correction model (ECM-ARDL)*

Table 7. The estimates of the ARDL model and error correction model with breakpoint. Electricity consumption as energy variable

Long run relationship: estimating the eq.[2]		Short run relationship: estimating the eq.[3]	
Dependent Variable: Log CO$_2$		Dependent variable: Dlog CO$_2$	
ARDL(4,1,2,2,3,2)		ECM-ARDL(3,1,2,2,3,2)	
[1]	[2]	[3]	[4]
Variables	Coefficients	Variables	Coefficients
constant	-11.11***	Dlog CO$_2$(-1)	-0.17*
	(2.51)		(0.094)
logCO$_2$(-1)	-0.21	DlogCO$_2$(-3)	-0.06
	(0.138)		(0.073)
logCO$_2$(-2)	-0.17	Dlog GDP(-1)	1.47***
	(0.122)		(0.419)
LogCO$_2$(-4)	-0.16*	D(logGDP(-2))^2	-0.08***
	(0.98)		(0.031)
log GDP(-1)	1.8***	DlogElec(-2)	0.51**
	(0.512)		(0.216)
(logGDP(-2))^2	-0.09***	DlogImp(-1)	0.17
	(0.031)		(0.11)
logElec(-2)	0.59***	DlogImp(-2)	-0.22*
	(0.136)		(0.113)
logImp	0.31**	Dlog Imp(-3)	0.65***
	(0.125)		(0.107)
logImp(-3)	0.48***	DlogExp	-0.39***
	(0.129)		(0.071)
logExp	-0.39***	DlogExp(-2)	-0.30***
	(0.078)		(0.071)
logExp(-2)	-0.30***	EMC(-1)	-0.97***
	(0.086)		(0.218)
Break	-0.13**	DBreak	-0.25***
	(0.060)		(0.058)
Akaike info criterion	-1.88	Akaike info criterion	-2.21
Schwarz criterion	-1.35	Schwarz criterion	-1.69
Durbin Watson test	2.24	Durbin Watson test	1.72
LM-test	1.95	LM-test	1.80
Prob(LM-test)	0.37	Prob(LM-test)	0.40
ARCH-test	0.24	ARCH test	0.14
Prob(ARCH)	0.62	Prob(ARCH)	0.69
Normality (JB)- test	0.95	Normality- JB-test	1.28
Prob(JB)	0.61	Prob(JB)	0.52

*Note: Standard errors in brackets. ***, **, * denotes significance at 1%, 5% and at 10% respectively. Also, the AIC and SC are used to select the optimum number of lags in the ARDL model and the error correction model (ECM-ARDL)*

Figure 1. Evolution of CO_2 emissions and real GDP in per capita terms in Algeria (1970-2010)

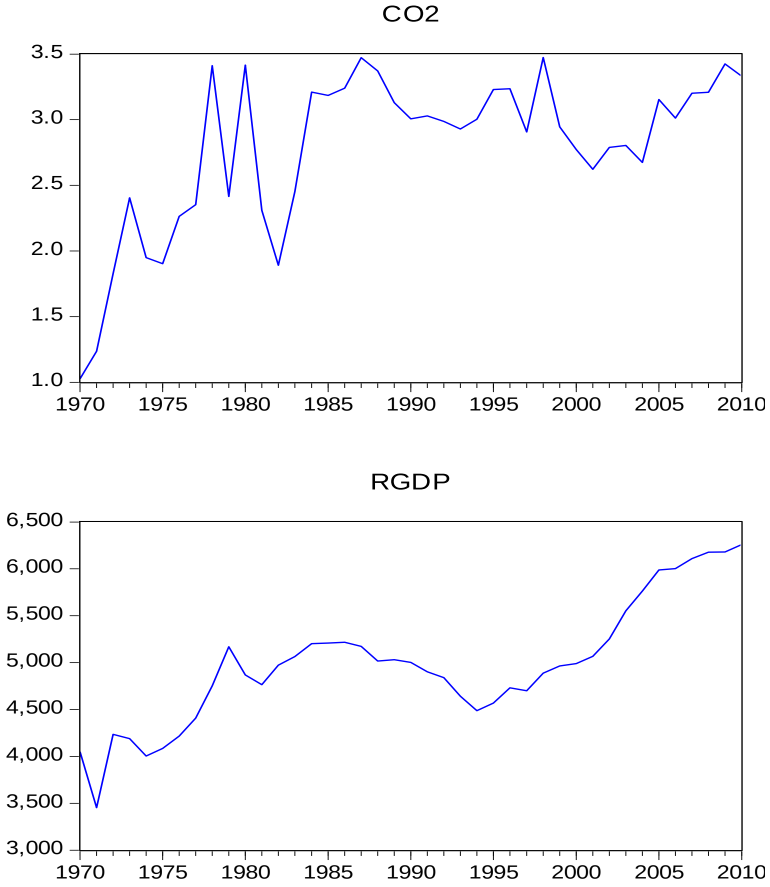
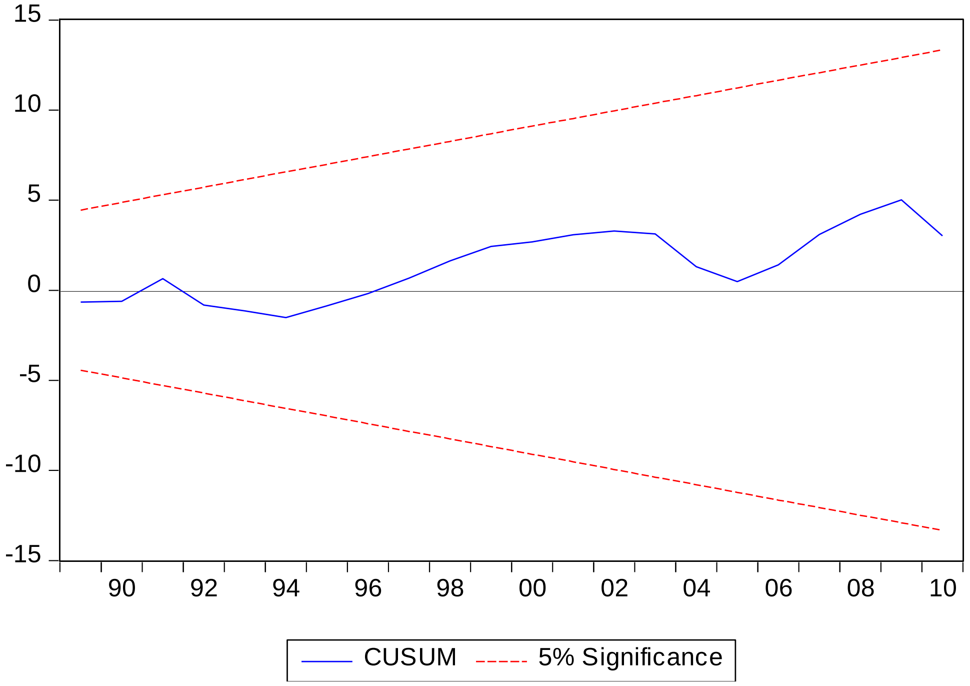


Figure 2: Graphics of stability test on the residual related to eq.[3] (Energy use)



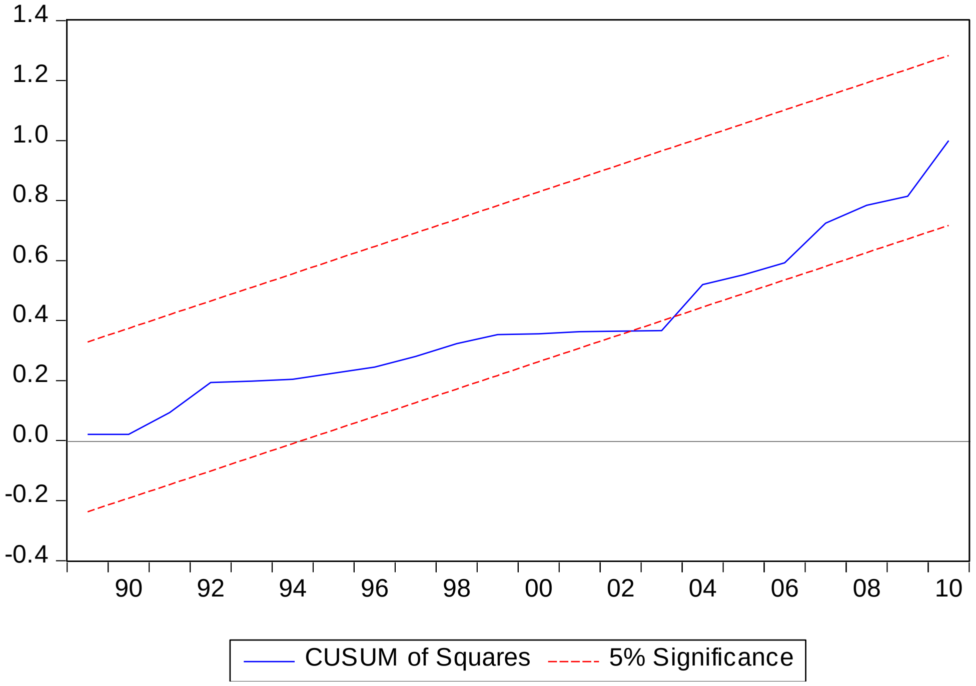


Figure 3. Graphics of stability test on the residual related to eq.[3] (Electricity consumption)