An Empirical Test on the Environmental Kuznets Curve Hypothesis in Algeria: An ARDL/bounds and Toda-Yamamoto approaches

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Abstract:

This study aimed to examine the validity of Environmental Kuznets Curves in Algeria for the period 1990 to 2019 by employing the ARDL bounds and Toda-Yamamoto approaches.

This study found:

(i) The results of the ARDL suggest a long-run equilibrium relationship between carbon environmental degradation (CO2 emissions) and this determinants (ii) the impact environmental degradation (CO2 emissions) is positively correlated with the Gross Domestic Income (GDP) (iii) there exist an inverted U relationship between environmental degradation (CO2 emissions) implying the validity of environmental Kuznets Curve Hypothesis in Algeria (iv) according to Toda-Yamamoto causality results, there is unidirectional causality flowing from Gross Domestic Income to CO2 emission and There is bi-directional causality flowing from energy consumption to CO2 emission and There is bi-directional causality flowing from energy consumption to CO2 emission.

Keywords: EKC Curve, GDP, ARDL/bounds test, Toda-Yamamoto causality, Algeria.

JEL Classification Codes: C22, E62, O40

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1. INTRODUCTION

The new growth theory establishes, among other things, that postulates a relationship between economic growth and environmental degradation such that in the early stage of economic growth, the rate of environmental depletion would be on the rise and as income rises above some threshold level the magnitude of environmental impacts due to economic activity would begin to fall. So the EKC curve become an independent research issue and motivated a bulky number of studies. EKC claims an inverted U-shaped relationship between economic growth and environmental. The EKC curve is similar to the other relations developed by the authors (Rahn & Fox, 1996) and (Barro, 1990)–the so-called BARS curve takes its name from Barro, Armey, Rahn, and Scully. The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita In the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita, which will vary for different indicators, the trend reverses, so that at high income levels economic growth leads to environmental improvement. This study attempts to answer two research questions related to economic growth and environmental degradation in the context of Algeria: (a) can economic growth increase or decrease environmental degradation? (b) is it possible to empirically verify the existence of the Kuznets curve (EKC) in the case of Algeria?

The hypotheses of the study:

GDP increases or decreases CO2 emission in the context of Kuznets curve (EKC) exists hypothesis

The approach and objectives of the study:

This study examines the existence of Kuznets curve (EKC) exists hypothesis between economic growth and environmental degradation in Algeria for the period 1990-2019 using using the Autoregressive distributed lag (ARDL) bounds approach for co- integration in order to test the long run relationship between the variables subject of study.

The rest of the paper is organized as follows. Section 2 provides a brief review of the literature. Section 3 explains the model specification, data and methodology. Section 4 discusses the empirical results. Section 5 concludes

the research paper.

2. LITERATURE REVIEW

According to (Koop & Tole, 1999) ; (Shahbaz & Al, 2017); (Sahar & Ruhul, 2014), These studies explore the determinants of CO2 emissions, The empirical results show that non-renewable energy consumption increases CO2 emissions, whereas renewable energy consumption decreases CO2 emissions. (Faisal et al, 2018) examine the relationship between renewable energy consumption and non-renewable energy consumption and CO2 emissions for Pakistan by using auto-regressive distributive lag (ARDL) model of data from 1970 to 2016. The disaggregate analysis reveals that renewable energy consumption has an insignificant impact on CO2 emission in Pakistan and that, in the non-renewable energy model, natural gas and coal are the main contributors to the level of pollution in Pakistan. Economic growth positively contributes to CO2 emission in the renewable energy model but not in the non-renewable energy model. We now provide a brief review of the growing body of literature investigating this topic.

In the same line of research, (Alrajhi & Bashier, 2016, p. 14) using an Autoregressive Distributed Lagged (ARDL) bounds testing approach to estimating the validity of Environmental Kuznets Curves, in Saudi Arabia economy by using the data for the period 1971-2013.The ARDL results show that there is a long-run equilibrium relationship among Carbon Dioxide emission (CO2), economic growth energy consumption, and population density. Also. The Non-Granger causality results reveal bidirectional causality between economic growth, energy consumption, population density, and CO 2; economic growth and population density, energy consumption and population density, whereas, unidirectional causality runs from CO 2 to population density. EKC Hypothesis is valid in Saudi Arabia. (Zouhair & Alsamara, 2017, p. 1366) Using an Autoregressive Distributed Lagged (ARDL) approach to explores the validity of the Environmental Kuznets Curve (EKC) using two different environment indicators: the carbon dioxide emissions (CO2) and the ecological footprint in Qatar over the 1980–2011 period economy .The ARDL results show that there is a long-run equilibrium relationship among the selected variables. Also, the inverted U-

shaped hypothesis is not valid in Qatar when we use the CO2 emissions, whereas the inverted U-shaped held when using the ecological footprint. EKC Hypothesis is non-valid in Qatar.

(Alm & al, 2016, p. 560) Using an Autoregressive Distributed Lagged (ARDL) approach to explore the relationships between carbon emissions and their main determinants such as energy consumption, real income, and international trade, level of education and level of urbanization in Russian over the 1991–2016. According to the Kuznets curve Hypothesis. The ARDL results show that there is a long-run equilibrium relationship among the selected variables. Also, Energy consumption, real income, education and urbanization levels are found to be significant determinants of carbon emissions, while trade openness does not have an impact. The Granger causality test indicates two-way relationships between carbon emissions and energy use, real income and education. (Omisakin, 2009, p. 14) Using a Johansen Cointegration and Granger Causality to investigate the relationship between Economic Growth (GDP) and environmental quality in Nigeria, over the 1970–2015. According to the Kuznets curve Hypothesis. The Johansen Cointegration results show that there is a long-run equilibrium relationship among the selected variables. Also, Interestingly, the curve depicts a 'U-shaped' rather than an 'inverted U-shaped' curve (as suggested by the EKC hypothesis), meaning that with increase in income, carbon emission first experiences a declining trend and then starts rising again. Also, the study reveals that there is no causal or long run relationship between carbon emissions and income in Nigeria. (Sisay & Balazs, 2020, p. 4) using a Pooled Mean Group (PMG) approach to explains the relationship between economic activity and environmental degradation for 12 East African countries, over the 1990–2013. According to the Kuznets curve Hypothesis. The Pooled Mean Group (PMG) results show that there is a long-run equilibrium relationship among the selected variables. Also, the result shows that the relationship between per capita income and CO2 emissions (a proxy for environmental degradation) is bell shaped and thus is an extended version of the original inverted U-shaped curve relationship between economic activities and environmental degradation.

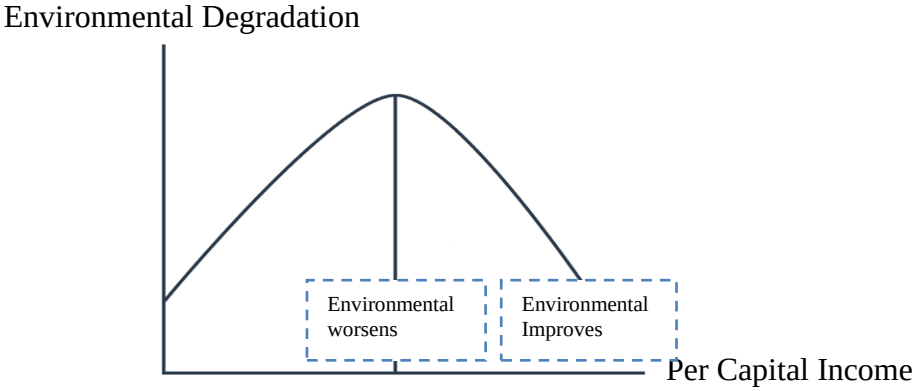
3. THEORETICAL FRAMEWORK OF THE ENVIRONMENTAL KUZNETS CURVE

Economist Simon Kuznets formulated the concept of "Environmental Kuznets Curve (EKC)" in the 1950s and 1960s, who proposed in 1955 the homonymous curve this hypothesized association between economic growth and income inequality, and found an inverse U relationship between them. In the 1990s, the Kuznets curve was examined as the Environmental Kuznets Curve (EKC), which stated an inverse U relationship between emissions and income, is termed inverted U-shaped. This phenomenon is also referred as Environmental Kuznets Curve (EKC) in Growth theory literature, named after Kuznets (1955), who described an inverted U-shaped association between emissions and income. The Kuznets Curve is a hypothesized relationship between various indicators of economic growth and Environmental. In the early stages of economic growth, environmental pressure increases up to a certain level as income goes up; after that, it decreases (Kuznets, 1955) ; (Eunho & al, 2010, p. 4)

In this way the "Environmental Kuznets Curve", is formulated, and according to it, environmental quality deteriorates at the early stages of economic development/growth and subsequently improves at the later stages. In other words, environmental pressure increases faster than income at early stages of development and slows down relative to GDP growth at higher income levels. Graphically, then, the relation between the Environmental Degradation and the Per Capital Income follows an upside-down U-shaped curve.

An example of an estimated Environmental Kuznets Curve is shown in **Figure.01**. Demonstrates the relationship between the share of the Per Capital Income and Environmental Degradation.

Fig.1. the Kuznets curve



Source: Eunho Choi et al (2010), An Empirical Study of the Relationships between CO2 Emissions, Economic Growth and Openness, IZA Discussion Paper No. 5304, P03.

4. Methods and Materials

This study analyzes the EKC hypothesis in Algeria by using an annual time series data over the period 1990-2019, the data is derived from International Energy Statistics, World Development Indicators (WDI) and Emissions Database for Global Atmospheric Research (EDGAR). For the and to investigate the causal linkages between per capita CO2 emissions (CO2), energy consumption (EC), real GDP. The following reduced-form equation model by Grossman and Krueger (1995) and Based on EKC hypothesis, a non-linear quadratic association exists between CO2 emissions and GDP. Hypothesis may formulate that EKC as follows:

Hypothesis may formulated that Armey Curve as follows:

$$CO2 = f (GDP, GDP^2, EC)\ldots\ldots\ldots\ldots (1)$$

Where:

- CO2; CO2 emission (metric tons per capita)
- GDP ; Gross Domestic Income
- GDP^2; the square value of Gross Domestic Income
- EC ; Energy Consumption

To reduce the variation and induce stationary in the variance-covariance matrix, the natural logarithmic form (Ln) is applied to all the

variables. The log linear equation to examine the longrun relationship between variables is given as follow:

$$LnCO2=\alpha_0 + \alpha_1 LnGDP+\alpha_2 GDP^2+\alpha_3 LnEC + \varepsilon_t \ldots.. (2)$$

To estimate equation (2) in the long run, we will use the ARDL model used by Pesaran and Shin (1999) and then extended by Pesaran et al. (2001), as the ARDL methodology does not require that the time series of the variables under study are not of the same rank, ie, both the I (0) and the I (1) Provided that the time series of the variables under study are not in the second difference I (2). The ARDL methodology is characterized by a set of characteristics that distinguish it from other standard methods; all variables of the model are assumed endogenous. (Jonas, 2018, p. 4); (Davidescu, 2015, p. 40)

- ✓ Bounds test method for cointegration is being applied irrespectively the order of integration of the variable.
- ✓ There may be either integrated first order I(1) or I(0).
- ✓ The short-run and long-run coefficients of the model are estimated simultaneously. An ARDL representation of equation (1) is formulated as follow :

$$\begin{aligned}\Delta LnCO2_t =& \propto_0 + \sum_{i=1}^{m} \propto_{1i} \Delta LnCO2_{t-i} + \sum_{i=0}^{m} \propto_{2i} \Delta LnGDP_{t-i} \\ &+ \sum_{i=0}^{m} \propto_{3i} \Delta LnGDP^2{}_{t-i} + \sum_{i=0}^{m} \propto_{4i} \Delta LnEC_{t-i} \\ &+ \propto_5 LnCO2_{t-1} + \propto_6 LnGDP_{t-1} + \propto_7 LnGDP^2{}_{t-1} \\ &+ \propto_8 LnEC_{t-1} + \varepsilon_t \ldots\ldots 03\end{aligned}$$

After regression of Equation (03), the Wald test (F-statistic) was computed to differentiate the long-run relationship between the concerned variables, bound testing under Pesaran et al (2001) procedure is used, and the bound testing procedure is based on the F test. The F test is actually a test of the hypothesis of on coinetegration among the variables against the existence or presence of cointegration among the variables denoted as : Ho: $\alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$, i.e., there is no cointegration among the variables H1 : $\alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq 0$, i.e., there is cointegration among these variables. Therefore,

if the computed F-statistic is smaller than the lower bound value, then the null hypothesis is not rejected and we conclude that there is no long-run relationship between. Conversely, if the computed F-statistic is greater than the upper bound value, then CO2 and its determinants share a long-run level relationship. On the other hand, if the computed F-statistic falls between the lower and upper bound values, then the results are inconclusive, according to (Sankaran & al, 2019) inconsiderate to the state that whether the variables are I(0) or I(1), the ARDL bound estimation will divulge the existence of the linear relationship among the non-stationary or mixed form of variables, but this test does not reveal the direction of the relationship among the considered variables. Hence, in order to understand the cause and effect direction among those variables in general, and with special reference to the relation between GDP and CO2 emission , this study employed Modified Wald test (MWALD) as suggested by Toda and Yamamoto (1995). The MWALD test emerged as a major improvement over the traditional Granger causality test as the latter test failed to consider the possibility of a non-stationarity or any cointegrating relationship, if at all, among the variables (Wolde-Rufael, 2005). The Toda and Yamamoto (1995) exercise applies a standard VAR model while variables are in levels rather than first differences (unlike Granger causality test) implying that the risk of wrongly identifying the order of integration of the series is minimized

5. RESULTS AND DISCUSSION

5.1 Result of Unit Root Test:

Table 01; shows the test of stationary result, from the table we see that EC is stationary at level and variable GDP, GDP^2, CO2 are no stationary at level but stationary at 1^{er}difference with 5% significance level. As all the variables are found to have the order of I(0) and I(1), we choose to employ ARDL bound test in order to determine the long-run cointegration between GDP , GDP^2, EC with CO2 emission in Algeria.

Table 1. Unit root test (ADF)

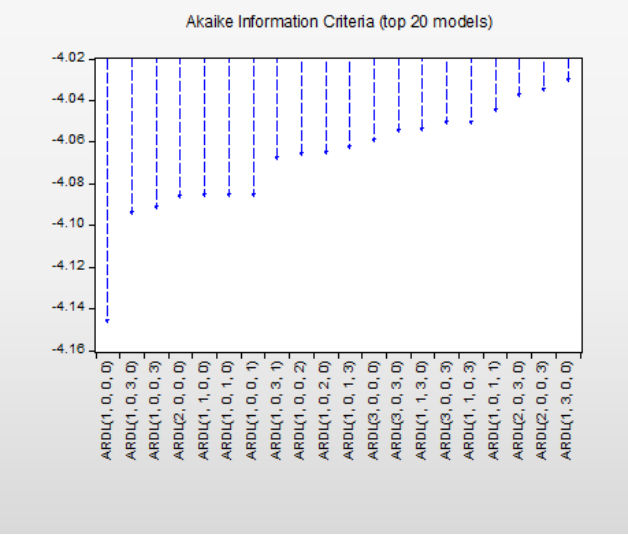
Variables	CO2	GDP	GDP^2	EC
results	I(1)	I(1)	I(1)	I(0)

Source: Eviews 09 output

5.2 Optimal Lag:

According to the akaike information criteria the optimal of ARDL is ARDL (1, 0, 0, 0)

Fig .2. Optimal Lag



Source: Eviews 09 output

5.3 Result of ARDL Bound Test:

In **Table 02**; the results of the bounds cointegration test demonstrate that the null hypothesis of against its alternative is easily rejected at the 5% significance level, the computed F-statistic of 6.749964 is greater than the lower critical bound value of 3.23 thus indicating the existence of a steady state long-run relationship among CO2 emission and its determinants.

Table 2. Bounds Test Result

ARDL Bounds Test
Date: 10/30/20 Time: 16:33
Sample: 1981 2015
Included observations: 35
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	6.749964	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Source: Eviews 09 output

5.4 Long and Short-Run estimates of ARDL Approach:

In Table 3; shows the long run coefficient of ardl model, from the we can see that the according to long run coefficients of Gross Domestic Income (GDP), the square value of Gross Domestic Income(GDP^2) and energy (EC) Algeria are statically non-significant in levels at 1%, 5%, 10%. On the other hand, the results show that CO2 emission is positively correlated with the Gross Domestic Income (GDP), this indicate that an increase in Gross Domestic Income (GDP) can enhance CO2 emission. The results also show that the CO2 emission is negatively correlated with the square value of Gross Domestic Income (GDP^2). Also, energy consumption (EC) has the expected positive impacts on the level of CO2 emission.

In Table 3; shows the short run coefficient of ARDL model, with the table we can see that the sign of lagged error correction representation (ecmt-1) is negative and statistically significant. On the other hand, the (ecmt-1) shows the speed of adjustment toward equilibrium, approximately, -0.459697 disequilibria from the previous year's shock converge on the long run

equilibrium in the current year. Also are statically significant in levels at 1%, 5%, 10%.

Table. 3. ARDL Cointegrating and Long Run Form

ARDL Cointegrating And Long Run Form
Dependent Variable: CO2
Selected Model: ARDL(1, 0, 0, 0)

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EC)	0.621150	0.200004	3.105690	0.0041
D(GDP)	0.173233	2.384956	0.072636	0.9426
D(GDP^2)	-0.038338	0.350107	-0.109505	0.9135
CointEq(-1)	-0.459697	0.128795	-3.569201	0.0012

Cointeq = CO2 - (1.3512*EC + 0.3768*GDP -0.0834*XGDP + 2.6649)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EC	1.351218	0.320750	4.212682	0.0002
GDP	0.376842	5.203429	0.072422	0.9427
GDP^2	-0.083400	0.764878	-0.109036	0.9139
C	2.664905	9.125631	0.292024	0.7723

Source: Eviews 09 output

The results show that CO2 emission is negatively correlated with the squares of Gross Domestic Income(GDP^2), The study provides an evidence that there exists an inverted U relationship between Gross Domestic Income and CO2emission implying the validity of Kuznets curve in Algeria.

According to **Long and Short-Run results** results, we determine Environmental Degradation using differentiating the equation ($\alpha_1/-2\alpha_2$), the mechanism specified below calculates the Environmental Degradation using first differentiation:

$$CO2= 2.66 + 1.35EC+0.37GDP-0.08\ GOV^2 \ldots\ldots (4)$$

Calculate the first derivative:

$$\frac{\mathrm{d}(\mathrm{CO2})}{\mathrm{d}(\mathrm{GDP})} = 0.37 - 2(0{,}08)\mathrm{GDP}$$

Equalize the values to zero to calculate the Environmental Degradation

$$0.37 - 2(0{,}08)\mathrm{GDP} = 0 \leftrightarrow \mathrm{GDP} = 0{,}21$$

Therefore, Environmental Degradation of Algeria is 21%. These findings provide evidence supporting the presence of can inverted "U" shaped relationship between Environmental Degradation and Per Capital Income in Algeria for the period 1990-2019.

5.5 Long and Short-Run estimates of Ardl Approach:

After estimating long-run results, we proceeded to causality test. From the estimation of the Toda Yamamoto Granger causality test (see Table 04.), the study attained a kaleidoscopic result, there is unidirectional causality flowing from Gross Domestic Income to CO2 emission and There is bi-directional causality flowing from energy consumption to CO2 emission.

Table. 4. Yamamoto Causality test

Null Hypothesis	Chi-Sq	Prob	Granger Causality
GDP does not granger cause CO2	3.231542	0.0023	Unidirectional Causality (GDP ⟶ CO2
CO2 does not granger cause GDP	0.326574	0.4230	
GDP^2 does not granger cause CO2	0.369254	0.3251	No Causality
CO2 does not granger cause GDP^2	1.006501	0.7452	No Causality
EC does not granger cause CO2	0.321521	0.0285	bi-directional Causality EC ⟷ CO2
CO2 does not granger cause EC	0.876952	0.0127	
GDP does not granger cause GDP^2	0.526524	0.2574	No Causality
GDP^2 does not granger cause GDP	0.465213	0.1752	No Causality
GDP does not granger cause EC	0.132536	0.1250	No Causality
EC does not granger cause GDP	0.743625	0.9127	No Causality
EC does not granger cause GDP^2	0.263140	0.2147	No Causality
GDP^2 does not granger cause EC	0.723241	0.2564	No Causality

Source: Eviews 09 output

6. CONCLUSION

This study analyzes the EKC hypothesis in Algeria by using an annual time series data over the period 1990-2019 by employing ARDL and bounds test approach. According to the Kuznets Curve Hypothesis. The results show that:

- The literature indicating that the environmental Kuznets curve is a relationship between various indicators of environmental degradation and income per capita. The EKC hypothesis states that environmental degradation worsens as economic development increases, however after reaching a certain level of GDP per capita, it begins to decrease.
- The variables are found to have the order of I(0) and I(1), we choose to employ ARDL bound test in order to determine the long-run cointegration.
- There exists a long run equilibrium relationship between the CO2 emission and this determinant.
- CO2 emissions is positively correlated with the Gross Domestic Income (GDP), also CO2 emissions is negatively correlated with the square value of Gross Domestic Income (GDP^2).
- Energy consumption (EC) has the expected positive impacts on the level of CO2 emission.
- There exists an inverted U relationship between the Gross Domestic Income GDP) and environmental degradation (CO2 emission) implying the validity of environmental Kuznets curve Hypothesis in Algeria.

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