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RESEARCH ARTICLE

AN EMPIRICAL ANALYSIS ON THE INDUSTRIAL WATER POLLUTION AND ECONOMIC GROWTH IN ALGERIA

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ABSTRACT

This paper investigates the long termed relationship that exists between the Algerian economic growth and its industrial water pollution during the period 1975-2005. The Biochemical Oxygen Demand per worker (BOD) for Algeria was utilized as the environmental indicator, whereas the GDP per capita was utilized as its economic indicator and using other explanatory variables such as, exports, imports and population growth which may influence the environmental degradation in Algeria. The Auto Regressive Distributed Lag (ARDL) methodology was used to test the Environmental Kuznets Curve (EKC) hypothesis, and its empirical findings suggest that there exists a long term relationship between per worker BOD emissions on one hand and the real per capita GDP (Gross Domestic Product) on the other hand. Accordingly, there is an inverted-U formed relationship that lies between the GDP and the BOD emissions, and the fact that supports the EKC hypothesis is that this relationship stands in both short and long terms. On the other hand, the causality relationship between the BOD emissions and the economic growth turned out to be absent when tested by the Granger Causality test while based on the Vector Error Correction Model (VECM) in the short term. However, in the long term, it represented a uni-directional causality when reversed from the economic growth to BOD emissions.

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INTRODUCTION

Environmental pollution has become subject to major interests in recent years, particularly in economic researches. Different studies have successively been conducted to investigate the effects of economic growth on the environmental quality, in other words, whether increase in income improves or worsens environmental quality. In this research paper, we present the Environmental Kuznets Curve (EKC) for depicting environmental pattern. It has been called EKC due to its resemblance to the relationship underlying the per capita income and the level of inequality which was considered by Simon Kuznets (1955) in his famous book entitled *Economic Growth and Income Inequality*. The Environmental Kuznets Curve (EKC) theory has an important hypothesis, it has been expressed by inverted -U- income – inequality relationship that is whenever the per capita income increases, so does the inequality increase, until a certain point termed the "income turning point". After this point, the inequality starts to decrease, while the per capita income keeps increasing. A resemblance of this theory was noted by Grossman and Kruger (1991) through their empirical study. They tested the validity of the hypothesis of Environmental Kuznets Curve and found that there exists a relationship between economic growth and environmental degradation which is shaped as an inversed-U, and this relationship is measured by environmental indicators, such as per capita CO_2, BOD, SO_2 …etc. emissions and economic activities, which are measured in terms of "Income per Capita". This means that environmental degradation increases as percapitain come increases at the first phase of economic growth, however, when the rise in per capita income passes beyond the income turning point, the environmental degradation would contrarily begin to decrease. So the Environmental Kuznets Curvehypothesis illustrates that when a country starts to develop its industry, the environmental degradation increases accordingly to it, and it starts to decrease when it reaches a certain level of economic development (Figure 1). It indirectly suggests that environmental degradation cannot be avoidable in the first phase of economic growth. Panyotou (2003) suggested several reasons for this inversion in pollution patterns. First, the income turning point of pollution is caused by the rich and advanced societies, the fact which makes cleaner environments very valuable, and so, it brings both institutional and non-institutional actions into account of consideration in order to change the situation. Second, pollution is bound to increase at the first stage of industrialization because of inefficient, rudimentary and pollution generating industries appearing on the industrial arena. When industrialization starts to achieve more advanced levels untilitis sufficiently advanced, the pollution will stop increasing anymore.

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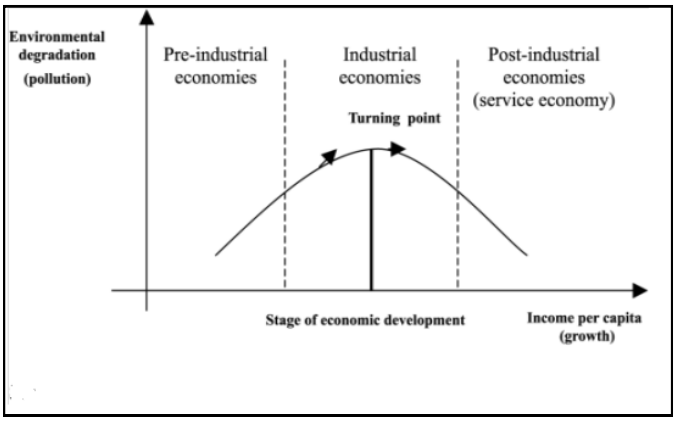


Source: Panayotou 1993

Figure 1. The Inverted U-shape of Environmental Kuznets curve

Rather, it will start to take a U-turn. Moreover, service industries will gain prominence causing a further reduction in pollution. After Grossman and Kruger's (1991) study, many empirical studies appeared to examine whether the EKC model is valid around the world. Yi Chia Wang *et al.,* (2011), Reka Homordi *et al.,* (2009), Lucena (2005), Michael Tuker (1995), and Fodah *et al.,* (2010)also found significant evidence of prevalence of Environmental Kuznets Curve in individual countries as well as in a set of countries, with different environmental indicators such as CO_2, SO_2, BOD etc. The applied studies which examine the validity of EKC hypothesis in Algeria are very limited, where, Algeria usually is classified with a specific country divisions like oil export countries, MENA countries, and African countries and so on. Our study focuses on the relation between the industrial water pollution indicated by the Biochemical Oxygen Demand (BOD) and the economic growth and some explanatory variables. The Following literature contains the case of Algeria in some aspects for the water pollution we present them as follows:

SerkanGürlük (2009) conducted a study that tackled the case of Biochemical Oxygen Demand (BOD) and its differences between countries north and south of the Mediterranean. Based on this research, Algeria is found to have a noteworthy result of GDP and MHDI (Modified Human Development Index) with BOD. The major findings of this research concluded that human development is highly important for Algeria and other developing Mediterranean countries such as Tunisia, Morocco…etc. Christopher O. Orubu *et al.,* (2011) also conducted a research that examined the relationship between the African per capita income and the African environmental degradation. The empirical results primarily suggested that there is a validity in the environmental Kuznets curve. In the case of the increase of per capita income, it was found that the organic water pollutants increase as well. However, when compared to evidence from the other existing studies mentioned in this particular research, the levels of income turning point which were calculated for the two proxies of environmental quality were generally low. This suggests that African countries can rapidly achieve the turning income point of the environmental Kuznets curve (EKC) at lower levels of income, especially when paralleled with the revised environmental Kuznets curve. The findings also advocated that the economic growth and the rising incomes do matter in African countries, and that comes to limit the pollution caused by these pollutants. However, more rigorous policy measures, particularly at the industrial level are required to limit the environmental degradation from the pollutants of organic water. The main objective of the current study is to evaluate the nature of the long-term relationship between economic growth and environmental degradation in Algeria. Granger causality test was also undertaken to define the long as well as short term causality's direction between per capita income and environmental pressure. The balance of this research is organized in the following manner: the first section contains the introduction and discussion of the literature on EKC, the second section describes the information and the methodology, the third section demonstrates its results and the discussion, finally the fourth section brings the study to a conclusion.

Data

Our empirical analysis values the relationship between the real percapita GDP, exports, imports and population growth as explanatory variables on one hand, and Biochemical Oxygen Demand per worker (BOD) on the other hand, whichrepresentsthewaterpollutionfromindustrialsourcesasenvironmentalindicator. To examine the validity of EKC hypothesis by checking whether the additional explanatory variables effect or not the water pollution in Algeria.

- The BOD is seen as the cause of industrial and urban water pollution. The US Environmental Pollution Agency (EPA, 2008) indicated that the BOD is the amount of oxygen consumed in water by the bacteria while degrading the waste, and when water resources are overloaded with pollution, it decreases the content of dissolved oxygen which is a necessity for aquatic animals. This study's dataset emphasizes the pollution of organic water which is caused by industrial activities that are valued by the BOD (WRI, 2008).
- GDP is the yearly production of any given country's economy and it is here is in constant 2000 U.S. dollars. GDP per capita is the total GDP divided by the midyear population.
- The exported goods and services denote the value of all the market goods and services that are exported, which include the value of merchandise, transport, freight, insurance, license fees, travel, royalties etc., including other services, such as communication, information, construction, financial, business, personnel and government services. However, they exclude the compensation of employees and investment income (formerly called factor services) as well as transfer payments. Real data are taken in constant 2000 U.S. dollars.
- The imports of goods and services relate to the value of all market goods and services that are imported from other countries of the world. These contain the value of merchandise including all the goods and services mentioned in exports. On the other hand, they exclude the compensation of employees, the investment income and transfer payments. Real data are taken in constant 2000 U.S. dollars.
- Demographics (population growth in yearly percentage) denotes the exponential rate of the midyear population growth expressed in percentage (from year t-1 to t %).

This research uses the yearly data over the period ranging from 1975 to 2005. We use per worker Biological Oxygen Demand (BOD) emissions as the environmental indicators (kg per day per worker), real per capita GDP, export, Import (in constant 2000 US dollars) and Population growth.

Table 1. The Industrial Subsectors Influencing the BOD Emissions in Some North African Countries

Countries	Their industrial contributions to the BOD emission							
	Chemicals	Glass/ clay	Foodstuff	Metallic	Trash/ pulp	Fabric	Timber	Other
Egypt	8	0	50	12	8	19	0	3
Algeria	6	1	60	23	2	8	1	1
Morocco	8	6	22	1	3	43	2	14
Tunisia	5	0	36	3	6	43	2	5

Source: Serkan Gürlük (2009), "Carbon Dioxide Emissions and Economic Growth: Panel Data Evidence from Developing Countries" [45] (A Percentage of Total BOD Emissions).

All explanatory variables data utilized in the current study were taken from the World Bank's World Development Indicators CD-ROM (2012) in natural logarithm.

Table 2. A Summary of Descriptive Statistics

Variable	Mean	Standard Deviation	Max	Min
Ln BOD	11.50246	0.039496	11.55128	11.42579
Ln GDP_{PC}	7.513707	0.069163	7.656898	7.396569
Ln GDP_{PC}^2	56.46042	1.039766	58.62809	54.70924
Ln Export	23.50406	0.276144	24.03453	23.10792
Ln Import	23.42217	0.233976	23.86732	23.08086
Ln Pop	0.821180	0.336228	1.195311	0.352862

Source: Computed by Authors Using E-views 08 software.

Specification and Methodology of the Model

Model Specification

A quite standard parametric quadratic model in the EKC literature was considered in this study. The EKC model can be specified as follows:

$$\mathbf{E}=f(Y, Y^2, Z) \quad \ldots\ldots (1)$$

E refers to the environmental indicator, while Y indicates the income and Z refers to other explanatory variables which may affect the environmental degradation. The long term relationship amongst variables will be formed to assess the validity of the EKC hypothesis and the causal relationship amongst the income and the BOD emissions. When compared to the simple linear functional form of model, the linear model is transformed to a log-linear specification, since it provides more appropriate and efficient results. Thus, the equation is rewritten as follows:

$$LnE_t = \beta_0 + \beta_1 LnY_t + \beta_2 (LnY_t)^2 + \beta_3 LnX_t + \beta_4 LnM_t + \beta_5 LnP_t + \varepsilon_t \quad \ldots\ldots (2)$$

Where, E_t represents per worker BOD emissions, Y_t is the economic growth that is measured by the real GDP per capita, X_t is exports, M_t refers to imports, P_t represents the population growth rate and ε_t is a term that indicates a standard error. In line with EKC hypothesis the income coefficients values and signs for (β_1, β_2) indicate different functional forms. Where $\beta_1<0$and $\beta_2>0$ indicates a U-shaped relationship while $\beta_1>0$ and $\beta_2 < 0$ indicates an inverted U-shaped relationship. $\beta_1 = \beta_2 = 0$ reveals a level relationship, $\beta_1< 0$ and $\beta_2 = 0$ indicates a monotonically decreasing linear relationship, $\beta_1>0$ and $\beta_2 = 0$ indicates a monotonically increasing linear relationship. The income turning point of the real per capita income is obtained as follows:

$$\boldsymbol{\tau}= [-\beta_1/ (2\beta_2)] \quad \ldots\ldots (3)$$

METHODOLOGY

The aims of this empirical assessment are to test the way that the variables are interrelated in the long-term and to evaluate the active causal relationship amongst economic growth on one hand, and other explanatory variables with environmental indicators on the other hand. To keep up with these objectives, the followed methodological approach in the current study comes in the following structure: Firstly, test all the variables for stationary utilizing 2 unit root tests; the augmented Dickey–Fuller (ADF) test (Dickey and Fuller, 1979) and the Kwiatkowiski–Phillips–Schmidt–Shin (KPSS) test (Kwiatkowski *et al.,* 1992). The Unit root test provides the integration order of our variables, and helps in making sure that our series are integrated in levels I (0) or in order one I (1) or beyond. Second, based on the unit root test co-integration method will be chosen. If our variables are co-integrated, then we pass to estimate the Error Correction Model (ECM). Finally, the Granger causality tests are conducted to test the causality.

Unit Root Test

Unless its probability distribution changes over time, a time series Y_t is stationary. Stationarity requires the future to be similar with the past, at least on probabilistic measures [16]. Different tests are used to investigate whether our series subject of study are stationary or not such as, Phillips–Perron (PP) test (Phillips and Perron,1988), the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test (Kwiatkowski *et al.,* 1992) and the Augmented Dickey–Fuller (ADF) test (Dickey and Fuller,1979). The unit root tests are grounded on the following three regression forms:

Table 3. Different Regression Forms of Unit Root Test

Without Constant (Intercept) and trend	$\Delta Y_t = \delta Y_{t-1} + u_t$
With Constant (Intercept)	$\Delta Y_t = \alpha + \delta Y_{t-1} + u_t$
With constant (Intercept) and trend	$\Delta Y_t = \alpha + \beta T + \delta Y_{t-1} + u_t$

Source:http://staffweb.hkbu.edu.hk/billhung/econ3600/application/ app01/ app01.html

Unit Root Tests Hypothesis

1. ADF and PP tests
   - Null hypothesisH0 :δ=0 has Unit root (is not stationary)
   - Alternative hypothesisH1: δ≠0 Unit root exists not (stationary)
   - KPSS test
   - Null hypothesisH0 :δ=0 Unit root exists not (stationary)
   - Alternative hypothesisH1: δ≠0 has Unit root (is not stationary)

Decision rule:

If t* table > computed (t) for ADF, PP, KPSS ==> Accept null hypothesis.
If t* table < computed (t) for ADF, PP, KPSS (t) ==> Reject null hypothesis.

In case the series are not stationary in levels, usually the first difference is taken to make the series stationary. Also unit root test helps determine in which order the series subject of study are integrated e.g. I (0) in levels, or I (1) in first difference and so on.

Co-Integration

Various techniques are in use for conducting the co-integration analysis such as: the maximum likelihood-based approach that was proposed by Johansen and Julius (1990) and Johansen (1992), Engle and Granger (1987). Both approaches necessitate that the variables must share the order of integration. It is usually this necessity that makes it difficult for the researchers in cases where the system includes variables with diverse orders of integration. A new approach was suggested by Pesaran *et al.* (1996, 2001) to overcome this problem. This new approach, the Autoregressive Distributed Lag (ARDL) is used for co-integration test and it does not need the classification of variables into I (0) or I (1)[1]. The approach is also applicable for studies that use a moderately small-sized sample, as seen in the current study. The small model characteristics of the approach of the Autoregressive Distributed Lag (ARDL) are better and more sophisticated than the Johansen and Juselius (1990) co-integration technique as Pesaran & Shin demonstrated (1999). This method is also found to be highly advantageous due to the fact that it can guarantee an estimation even in the case of endogenous explanatory variables. Moreover, this method assures long and short-term parameters' estimation for variables under the same framework. For these advantages, Autoregressive Distributed Lag (ARDL) approach has gained popularity over recent years, and it is conducted as follows:

ARDL (1, 1) model: $y_t = \mu+\alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + u_t$…….(4)

Here y_t and x_t are considered as stationary variables, while u_t is a white noise[2]. The use of the lag operator L used for every constituent in a vector, $L^k x_t = x_{t-k}$ makes it easier to outline the lag polynomial A (L) and the vector polynomial B (L).

The ADRL (p,q) model:

With $A(L)y_t = \mu + B(L)x_t + u_t$, ………………………. (5)

$A(L) = 1 -\alpha_1 L -\alpha_2 L^2 - \dots - \alpha_p L^p$,…………………………... (6)

$B(L) = 1 -\beta_1 L -\beta_2 L^2 - \dots - \beta_q L^q$………………………….. (7)

Thus, the general ARDL (p, q1, q2, …,qk) model is:

$A(L)y_t = \mu+B_1(L)x_{1t} + B_2(L)x_{2t} + \dots + B_k(L)x_{kt} + u_t$ ……...(8)

[1]The major shortcoming in the ARDL approach is that it cannot provide vigorous outcomes in case the order of integration is more than one (e.g. I(2)).
[2] In a white noise process, an arbitrary operation of arbitrary variables that are not correlated and have mean zero with a limited variance.

In the case that A(L) = 1, the result would be a distributed lag model (no lags of y_t). If we treat the values of x_t as being uncorrelated with u_t, the result is that Ordinary Least Square Method would be consistent. On the other hand, the Ordinary Least Square Method would be inconsistent if x_t is at the same time determined with y_t while $E(x_t,u_t) \neq 0$. We can consistently estimate the ARDL models by ordinary least squares as long as the error term u_t can be assumed to be a white noise process, or is stationary and independent of x_t, x_{t-1}, … and y_t, y_{t-1} …etc. Fundamentally, the approach of bounds test includes 2 steps, starting by investigating the existence of long-term relationship between the variables subject of study, where Autoregressive Distributed Lag (ARDL) framework for this research is formulated as:

$$\Delta LnE_t = \delta_0 + \sum_{k=1}^{n} \delta_{1k}\,\Delta LnE_{t-k} + \sum_{k=1}^{n} \delta_{2k}\,\Delta LnY_{t-k} + \sum_{k=1}^{n} \delta_{3k}\,\Delta(LnY_{t-k})^2 + \sum_{k=1}^{n} \delta_{4k}\,\Delta LnX_{t-k} + \sum_{k=1}^{n} \delta_{5k}\,\Delta LnM_{t-k} + \sum_{k=1}^{n} \delta_{6k}\,\Delta LnP_{t-k} + \pi_1 LnE_{t-1} + \pi_2 LnY_{t-1} + \pi_3 (LnY_{t-k})^2 + \pi_4 LnX_{t-1} + \pi_5 LnM_{t-1} + \pi_6 LnP_{t-1} + \varepsilon t \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (9)$$

Where δ_0 refers to the drift component while Δ represents the first difference. The terms with summation sings are utilized to demonstrate the short-term dynamic structure, while π_i represents the long-term multipliers. The Scawrtz-Bayesian criteria (SBC) is used to choose the appropriate lag length. The F-test is the fundament of the test procedure. It is conducted by excluding the lagged level variables in the equation above. The Ordinary Least Square method (OLS) utilizes the Microfit 4.1 software to test the ARDL approach equation (9). The null hypothesis is tested of; H_0:$\pi_1=\pi_2=\pi_3=\pi_4=\pi_5=\pi_6=0$ against its alternative H_1: $\pi_1\neq\pi_2\neq\pi_3\neq\pi_4\neq\pi_5\neq\pi_6\neq0$ to determine the relationship of no co-integration. The calculated *F*-statistic is therefore paralleled with 2 sets of critical values given by Pesaran *et al.* (2001). The first set presumes that all variables are I(0), which is known as the lower critical bounds (LCB) and the other assumes that they are I(1) which known as the upper critical bounds (UCB) values. In case the calculated F-statistic is bigger than the upper critical bound value (UCB), the result would be the rejection of the null hypothesis of no co-integration. On the other hand, in case it is below the lower bound, the null hypothesis of no co-integration cannot be rejected, in other words we do not have a long term relationship between the variables subject to the research. Finally, in case it falls into the bounds, then the test would be inconclusive. Once co-integration test between the variables is set up, the next step involves the estimation of the next conditional ARDL long-term model:

$$LnE_t = \delta_0 + \sum_{k=1}^{n} \delta_{1k}\,LnE_{t-k} + \sum_{k=1}^{n} \delta_{2k}\,LnY_{t-k} + \sum_{k=1}^{n} \delta_{3k}\,(LnY_{t-k})^2 + \sum_{k=1}^{n} \delta_{4k}\,LnX_{t-k} + \sum_{k=1}^{n} \delta_{5k}\,LnM_{t-k} + \sum_{k=1}^{n} \delta_{6k}\,LnP_{t-k} + \varepsilon t \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (10)$$

All variables are defined as before, while the estimation of equation (10) involves the optimal lag orders of the Autoregressive Distributed Lag (ARDL) approach.

Error Correction Model

The Error Correction Models (ECMs) are a set of numerous series models that directly estimate how fast a dependent variable Y would go back to the equilibrium after a modification has occurred in an independent or explanatory variable X. Short-term active parameters of the present model related with the long-term estimates can be gained through estimating the next error correction model (ECM):

$$\Delta LnE_t = \delta_0 + \sum_{k=1}^{n} \delta_{1k}\, \Delta LnE_{t-k} + \sum_{k=1}^{n} \delta_{2k}\, \Delta LnY_{t-k} + \sum_{k=1}^{n} \delta_{3k}\, \Delta (LnY_{t-k})^2 + \sum_{k=1}^{n} \delta_{4k}\, \Delta LnX_{t-k} + \sum_{k=1}^{n} \delta_{5k}\, \Delta LnM_{t-k} + \sum_{k=1}^{n} \delta_{6k}\, \Delta LnP_{t-k} + \theta ECT_{t-1} + \varepsilon t \quad \ldots\ldots\ldots\ldots\ldots\ldots..(11)$$

ECT_{t-1} is the term of the error correction to our model. It measures how fast the prior deviations occurring from the equilibrium are corrected. The error correction term (ECT) must have a negative sign and statistically significant indicating a move back towards equilibrium. The step before the last is estimating the stability of coefficients through cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) which Brown *et al.* (1975) originally proposed. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) statistics get recursive updates and then they are designed against the break points of the model. The null hypothesis that all coefficients in the given regression are stable cannot be rejected in case that the plots of CUSUM and CUSUMSQ statistics can stay within the critical bounds of 5 percent level of significance. In other words, the model subject of study is stable within critical bounds of 5 percent significance level. Our model is stable within critical bounds of 5 percent significance because level the null hypothesis that all coefficients in the given regression are stable and cannot be rejected.

Granger Causality

The last phase is testing for causality by using the Granger causality test founded on the Vector Error Correction Model (VECM)

Granger causality test is a statistical term of causality which is founded on estimation. As reported by the Granger causality test, the past X values should include information that helps forecast Y above and beyond the information included in the past values of Y alone, in case a signal X G-causes (Granger-causes) a signal Y. The mathematical formulation of this test is founded on linear regression modeling of stochastic procedures. The ARDL method can only test whether a co-integration relationship exists among variables, but it cannot test the causality direction. The Vector Autoregressive (VAR) model is used to test the causality amongst the variables in case no co-integration exists between the variables in the model. Using the Granger and Engle (1987) [28] causality test by means of a VAR in the first difference variable would result in confusing outcomes, especially when a co-integration is present. The lagged error correction term (ECT_{t-1}) was obtained from the long-term co-integration relationship and contains it in the equation as a supplementary explanatory variable. The Vector Error Correction Mode can be designed as the following formula:

$$(1-\mathrm{B})\begin{bmatrix} lnE_t \\ lnY_t \\ lnY_t^2 \end{bmatrix} = \begin{bmatrix} C_1 \\ C_2 \\ C_3 \end{bmatrix} + \sum_{i=1}^{P} (1-B) \begin{bmatrix} d_{11,i} & d_{12,i} & d_{13,i} \\ d_{21,i} & d_{22,i} & d_{23,i} \\ d_{31,i} & d_{32,i} & d_{33,i} \end{bmatrix} \begin{bmatrix} lnE_{t-i} \\ lnY_{t-i} \\ lnY_{t-i}^2 \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} [ECT_{t-1}] \begin{bmatrix} \gamma_{1t} \\ \gamma_{2t} \\ \gamma_{3t} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

(1-B) is the lag operator and ECT_{t-1} is the lagged error correction component. D's are parameters that still need to be estimated while the γ_t's are residual terms that are uncorrelated arbitrary disturbance terms with a zero mean. The long-run co-integration VECM can be used to detect direction of causality, moreover the VECM can also be used to get the short-term as well as the long-term relationships, and the significance of its lagged ECTs can be used to establish the long-term causal relationship. The **t** test and the short- term Granger causality is identified via the significance of the F-statistics of Wald test for the lagged explanatory variables, where certain standards must be chosen to find the appropriate lag length, such as the AIC and SBC.

Major Findings

The Conduction of the Unit Root Test

The supposition of the bounds test is that the variables are either I(0) or I(I) but when we apply the ARDL procedure using the unit root test, it is obligatory to guarantee that the variables cannot be I(2) or beyond. The ADF and KPSS Unit root tests showed that all the sequences that are subject to the study belong to a non-stationary category in the levels at 5% significance level apart from LnY, $(LnY)^2$ and LnP. (See Table 4). ADF (H_0) =the sequence has a unit root. In order to choose the AIC we use the lag length. KPSS (H_0) =the sequence is stationary. For the spectral estimation method we use Barlett and Kernel methods. The Newey–West method is utilized to choose bandwidth. After using the I (1) first difference, the non-stationary, however, series can become stationary, the fact which may result in combined orders of I (0) and I (1) for integrations among our variables in the table above. Following the conclusions from the stationarity tests, we examine whether the co-integration between the variables becomes possible by following the method that Pesaran et al. (1996, 2001) designed (the Autoregressive Distributed Lag method (ARDL)), a co-integration test, in which there is no necessity to categorize the variables into I (0) or I (1). After this step, we may use unlimited VAR by using AIC and SBC to achieve the optimal lag length on the I (1) variables. We designed the optimum lag choice in the current research by setting the highest lag lengths up to 3 due to the low number of variables and sample size. When we select 3 as the highest lag length we can guarantee that the optimum order cannot not surpass it.

Table 4. Findings of the Unit Root Test

	Augmented Dickey–Fuller		Kwiatkowiski– Phillips–Schmidt–Shin		
Variables	Constant	Canst & trend	Constant	Const & trend	Decision
LnE	-1.64712	-1.994328	0.697723**	0.171643**	Non stationary
LnY	-4.6003***	-1.9943	0.103047	0.109634	stationary
$(LnY)^2$	-4.5732***	-3.6886**	-0.103098	0.109708	stationary
Ln X	0.4843	-2.5631	0.726250**	0.127338**	Non stationary
Ln M	-1.25056	-1.0895	0.329443	0.113156*	Non stationary
Ln P	-5.897063***	-5.341535***	0.662664	0.120081	stationary
ΔLnE	-6.0747***	-6.2573***	0.255191	0.126779	stationary
ΔLY	-3.0944**	-3.0869	0.202227	0.197872	stationary
$\Delta\ (LY)^2$	-3.07654**	-3.07204	-0.202823	0.19803	stationary
ΔLnX	-5.3463***	-5.4395***	-0.284555	0.18942	stationary
ΔLnM	-4.6574***	-4.705997***	0.171627	0.162477	stationary
ΔLnP	-1.884638	0.393561	0.173714	0.15311	stationary

Source: Computed by the Authors Using E-views Software. Note: (*), (**) and (***) signify the rejection of the null hypothesis at 10%, 5% and 1% significance levels consecutively.

The criteria utilized to define the optimal lag number is the SBC. Since the integration order among the variables subject of this study is determined, we employed F test to ensure any long-term or co-integration relationship among the variables. Placing the different order of lags is necessary for the variables in equation (9) due to the sensitivity of F test to the lag carried out for the first differenced variables I (1). Before we changed the structure of the lags to 2 and 3, the lag 1 had been fixed for all first differenced variables. Following Bahmani-Oskooee and Kantipong (2001)' Samreth, Sovannroeun (2008) and BehnazSaboori n (2012).

Table 5. F-Statistics of Bound Tests

Lags	1	2	3
F-statistic	1.6357	2.1033	7.5568***

Source: computed by Authors Using Microfit 4.1 software.
P.S.: ***, ** and * consecutively denote 1%, 5% and 10% of the level of significance. The critical values of bound test are: 10% CV [2.26, 3.35], 5% CV [2.62, 3.79], 1% CV [3.41, 4.68]. The critical values are cited in Pesaran et al. (2001, p. 300) "Table CI (iii) Case III: Unrestricted Intercept and No Trend".

The bounds of F-test for co-integration yielded arguments of a long-term relationship among industrial water pollution (BOD) as a proxy of environmental degradation and its causes. The calculated Fstatistic in lag 3 becomes larger than the upper bound (UCB) of the 1% critical values (CV), the fact which causes the rejection of the no-long-term-relationship-among-the-tested-variables null hypothesis, i.e.: it infers a co-integration or a long term relationship between the variables subject to the study. The obtained proof guarantees that it is impossible to estimate the relationship as unauthentic. Once a co-integration relationship has been found among our variables we move on to display the estimated long-run relationship coefficients.

Table 6. Estimation Results of the Long-Term

Variables	Coefficients	T-Ratio	P-Value
C	-102.0086	-2.5133	0.020***
LnY	28.5818	-2.6861	0.014***
$(LnY)^2$	-1.911	-2.6946	0.014***
LnX	0.22854	4.8423	0.000***
LnM	0.0050455	1.7167	0.101
LnP	0.5908	1.8355	0.81

R^2=0.98055; Adjested R^2= 0.97313; Durbin-Watson=1.7494; Akaike info criterion=106.5584; Sensitivity analysis: Schwarz criterion = 100.2530; Serial correlation LM= 0.43889 (0.515)***; F-statistic = 132.3044; Heteroscedisticity test = 0.19102 (0.665)***; Source: Computed by Authors Using Microfit 4.1 software, dependent variable is LnE Note: the optimum selected lag by the ARDL is (1,0,0,1,0,1) based on the SBC. *, ** and *** denote 10%, 5% and 1% significance levels consecutively.

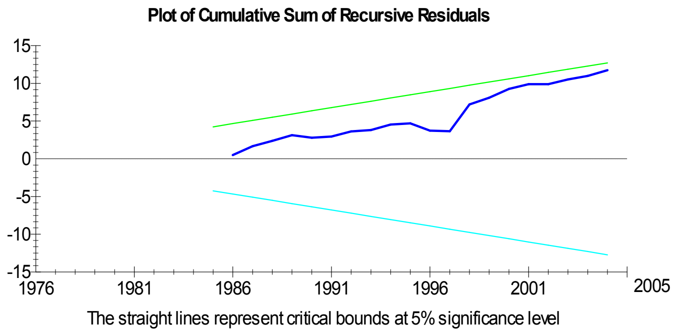
The optimum lag order selected by SBC for the ARDL model is (1, 0, 0, 1, 0, 1) as is represented in the next table. Not only are the long-term coefficients of the model significant at 1% and 10% level of significance, but also they appear with the right signs, except the Import (LnM) which became statistically insignificant in the long term. The diagnostic tests in the end of Table 6 suggested that the current model is specified well and is strong for the analysis of the policy, where the model passed the Heteroscedisticity test and serial correlation test successfully. The Durbin Watson test value was good and statistically significant. The independent variables involved clarify that around 97.313% of the variations in the environmental degradation, the fact which is demonstrated by the accustomed Rs quare. The diagnostic tests and the high value of R-squared confirm that the estimated model is well and that the long-term findings are stable. Table 7 indicates the short-term findings, where the Coefficient of the Loading Factor (ECT) is properly employed and statistically meaningful at 1% level of significance. This indicates that a mechanism of error correction occurs in order for the deviation from long-term equilibrium to have a substantial outcome on BOD of growth emission in Algeria.

Table 7. The Results of Error Correction Model

Variables	Coefficients	T-Ratio	P-Value
ΔLnY	14.7546	3.0679	0.005***
$\Delta(LnY)^2$	-0.98653	-3.0704	0.005***
ΔLnX	0.42733	1.2111	0.238
Δ LnM	0.027143	1.6482	0.113
Δ LnP	-0.020208	-3.935	0.001***
Δ C	-52.6591	2.8762	0.009***
ECT_{t-1}	-0.51622	-4.4108	0.000***

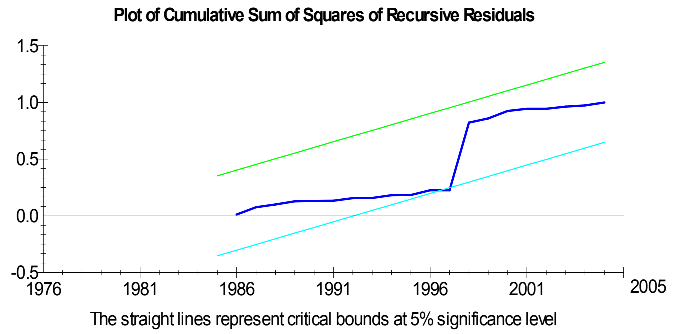
R^2=0.61097; Adjested R^2= 0.46276; Log-likelihood= 115.5584; F(6, 23)=5.4966***(0.001); Durbin-Watson= 1.7494**; ECTt-1 = LnEt-1 - 28.5818*LnYt-1 + 1.9110*(LnYt-1)2 -0.22854*LnXt-1 -0.0052579*LnMt-1 - 0.059080*LnPt-1+ 102.0086
Source: Computed by the Authors Using Microfit 4.1 software
Note: ARDL (1,0,0,1,0,1) chosen based on SBC. *, ** and *** consecutively indicate 10%, 5% and 1% level of confidence. Dependent variable is lnE.

The explanatory variables are vital in elucidating short-term variations in BOD emissions per-worker in Algeria. Except the exports (LnX) and imports (LnM*),* where these variables have only long-run impact on BOD emissions, while Population growth (LnP) was statistically significant whereas in the short term it participated negatively in the environmental degradation. As shown in the bottom of Table 7, the Durbin-Watson Statistic of 1.7494 clears all proofs that the model is auto-correlated. The global assessment is significant in the F-test. However, since merely 46.276% short-term environmental degradation variations are related to the involved variables, the accustomed R-square demonstrates a possibility that the model can be unfit. The CUSUM and CUSUMSQ tests need to be carried out in the present research in order to ensure that the assessed model is stable. The following figures (1 and 2) offer consecutively the charts of CUSUM and CUSUMSQ tests. The first figure indicates the stability of the plot of CUSUM within 5% of critical bounds. The deviation of the curve in the second figure, on the other hand, appears as passing due to the sign that the plot of CUSUMSQ is coming back again to the criteria bounds. The assessed ECM model can be viewed as stable because the plot of CUSUMSQ statistic goes entirely back to the middle of the criteria bounds.



Source: Compiled by Authors Using Microfit 4.1 Software

Figure 1. Plot of Cumulative Sum of Recursive Residuals (CUSUM)



Source: Compiled by Authors Using Microfit4.1 Software.

Figure 2. Plot of Cumulative Sum f Squares of Recursive Residuals (CUSUMSQ)

The last step is to examine the causality and its direction amongst the economic growth and BOD emissions by utilizing the Granger causality test. There is a causal relationship amongst the variables as is indicated by the long-term co-integrated relationship amongst BOD emissions per worker and real GDP per capita. We used the VECM Granger causality test to detect if the relationship seems to be uni, bi or no-directional.

Table 8. The Findings of the Granger Causality Test

	Short Run Granger Causality F-statistics [Prob]			**Long Run Granger Causality** ECT$_{t-1}$ (t-statistics)
	ΔLnE	ΔLnY	$\Delta (LnY)^2$	
Δ Ln E	----	6.900295[0.0034]	6.834140[0.0036]	-0.016748(2.972872)***
ΔLnY	1.219079[0.3350]	----	0.849529[0.4870]	
$\Delta (LnY)^2$	**1.208149[0.3387]**	**0.858783[0.4824]**	----	

Source: computed by Authors Using E-views 08 software.

From the table above, it is clear that the real GDP and the real GDP squared both Granger cause BOD releases in the long and short terms. The t-statistics of ECT$_{t-1}$ and F-statistic in Table 8 provide that there is a uni-directional long and short term Granger causality caused from the economic growth to the BOD releases. However, we did not find any evidence in favor of the reverse case for Granger causality neither in the long nor short terms. The results of these causality tests ensure that the EKC exists, thus, it pointed a similar end; that BOD releases are caused by a strong proof of existing income growth.

RESULTS AND DISCUSSION

The results of Unit root tests guarantee to us that the variables cannot be I (2) or beyond. The co-integration outcomes for long run coefficients estimation uncover an inversed U-shaped relationship amongst environmental degradation indicated by Biochemical Oxygen Demand (BOD) and per capita income in Algeria. The signs of the income variables ($\beta_1>0$, $\beta_2<0$) are the fundaments of the current deduction, where the non-positive sign of β_2 appears to support the breaking of the BOD releases as well as the real GDP in the greater level of revenue. Therefore, the results of this empirical research indicate that the theory of an environmental degradation with an inverted U-shaped EKC is represented by industrial water pollution (BOD) emissions per worker in Algeria. This result is fundamentally consistent with SerkanGürlük (2009) and Christopher O. Orubu *et al.,* (2011) where this tow studies found the existence of EKC for BOD in specific classification for Algeria within Mediterranean or African countries respectively. The results also are consistent with the findings of: BehnazSaboori (2012) in Malaysia, Fodha and Zaghdoud (2010) in Tunisia, Jalil and Mahmud (2009) in China, and Pao and Tsai (2011) in Brazil. The value of LnY 28.5818 indicates that any augmentation in the real GDP by 1% would automatically increase per worker BOD emissions by 28.5818 %, since the model is linear offered in a log-linear shape. We can also calculate the rest of the variables using the same method, where we find that the exports is relatively significant in the long run effecting BOD emissions, it has effect in water pollution from industrial source where the increase in real exports by 1% will rise the per worker BOD emissions by 0.228 %. That may be is due to the nature of Algerian exports which based on the hydrocarbons where 97% of Algeria exports are dominated by hydrocarbon exports, they pass definitely by the sea, during the shipment process some quantities of oil seep to the sea.

The import was not statistically significant to explain the long run influence to BOD emissions, while population growth also has a share in effecting the BOD emissions, where we found that the increase in LnP with 1% will raise BOD emissions with 0.590%, this is relatively high impact comparing to exports and imports, that is due to the unequal population distribution. Where, more than 63% of Algeria population live in 4% of national territory (costal area), also a huge amount of economic activities are stationed over there. This serious inequality in population distribution in Algeria creates a lot of environmental and economic problems. The long-term elasticity of BOD emissions according to GDP per capita is 28.5818LnY–1.9110 (lnY). The calculated turning point is around or equals $ 1768.42 (constant 2000 USD). According to the empirical results the income turning point for BOD lies inside data set, Algeria reached this turning point in 1998. The current empirical research proof is analogous to the results of BehnazSaboori (2012) in Malaysia and Fodha and Zaghdoud (2010) in Tunisia They also discovered that the turning point of the EKC is inside their experimental example period. On the other hand, Mahmud and Jalil (2009) in China discovered that the turning point of the EKC is outside their experimental example period. Passing to the ECM, the value -0.51622 indicates that about -51.622% of last year's imbalances in environmental degradation (BOD releases per worker) of the shock can change back into the long-term equilibrium in the present era. Judging by the income signs' terms, they offer a strong proof for EKC in the short term as well, and it was statistically significant. Moreover, the EKC is assumed to be a long-term phenomenon. Furthermore, it is also a short-run situation according to the obtained results. The general outcome denotes that economic growth participates considerably in BOD releases per worker in Algeria, in the long as well as short-terms, with highly qualified proofs that releases will be reduced in the long-term with the increase in the growth. The other explanatory variables were insignificant in clarifying the short-term modifications in BOD releases per-worker in Algeria, especially the Exports (LnX) and Import (LnM), which did not exert a short term influence on BOD, and they only had long-run impact on environmental degradation, while Population growth (LnP) was statistically significant whereas negatively participates to the short term environmental degradation. According to CUSUM and CUSUMSQ tests it can be said that the estimated ECM model is crudely stable. The Granger causality test indicated the presence of a uni-directional long-term causality starting from the economic growth to BOD emissions, however, the short-term causal relationship amongst economic growth and BOD emissions does not exist. This identical outcome was also found by the former researchers, such as Jalil and Mahmud in China, Maddison and Rehdanz (2008) in North America, Zhang and Cheng (2009) in China and Ghosh (2010) in India.

Conclusion

Based on the EKC theory, this study examined the both the long-term and causal relationships among economic growth and industrial water pollution represented by BOD, over the period of 1975–2005 in Algeria. Co-integration analysis was conducted using the Auto regressive Distributed Lag approach advanced by Pesaran *et al.,* (2001), in addition to the tests of causality and stability. The obtained consequences support the presence of an inverted-U shaped relationship among BOD releases and income in Algeria, based on short as well as long terms. The environmental policies may offer considerable facts about the causes of the detected inverted-U relationship among environmental degradation and revenues in the case of Algeria. In order to accomplish the results of co-integration analyses, the Granger causality was carried out to shed light on the causal link amongst revenue and environmental degradation represented by BOD in Algeria. The results of VECM Granger causality indicated the presence of a uni-directional causality relationship from economic growth to BOD emissions, in long as well as short –terms. On the other hand, it indicated the absence of the reverse case (from BOD to economic growth) of Granger causality, also in the long as well as short terms.

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