Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental Kuznets Curve

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Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental Kuznets Curve[1]

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Abstract

The Environmental Kuznets Curve (EKC) hypothesis is a presumption that environmental degradation follows an inverted U-shaped trajectory in relation to economic growth. The thorny question of whether economic growth could provide a cure to environmental degradation has sparked off a large body of empirical studies in the last decade. The conclusions have been mixed. This study contributes to the debate on the existence and policy relevance of the EKC for Nigeria by applying autoregressive distributed lag (ARDL) framework to annual time series data from 1960 to 2008. The traditional EKC model is extended by including (in addition to the level, square and cubed values of the income variable), trade openness as well as the shares of manufacturing, agriculture and service sectors in Nigeria's GDP. Using Co2 emissions per capita to proxy environmental degradation, our findings do not support the existence of the EKC hypothesis. Rather our results show that Nigeria's situation when confronted with data is exemplified by an N-shaped relationship with a turning point at $77.27 that lies below the data set used for the study. Based on these findings, the paper posit that the hypothesized EKC serves as a dangerous policy guide to solving environmental problems in Nigeria. The conclusion is that to ensure sustainability, there exist an urgent need to look beyond the EKC by adopting courageous policy measures of environmental preservation in Nigeria irrespective of the country's level of income.

Keywords: *Environmental Degradation, ARDL, Environmental Kuznets Curve, Nigeria*

JEL classification: *C32, Q24, Q4*

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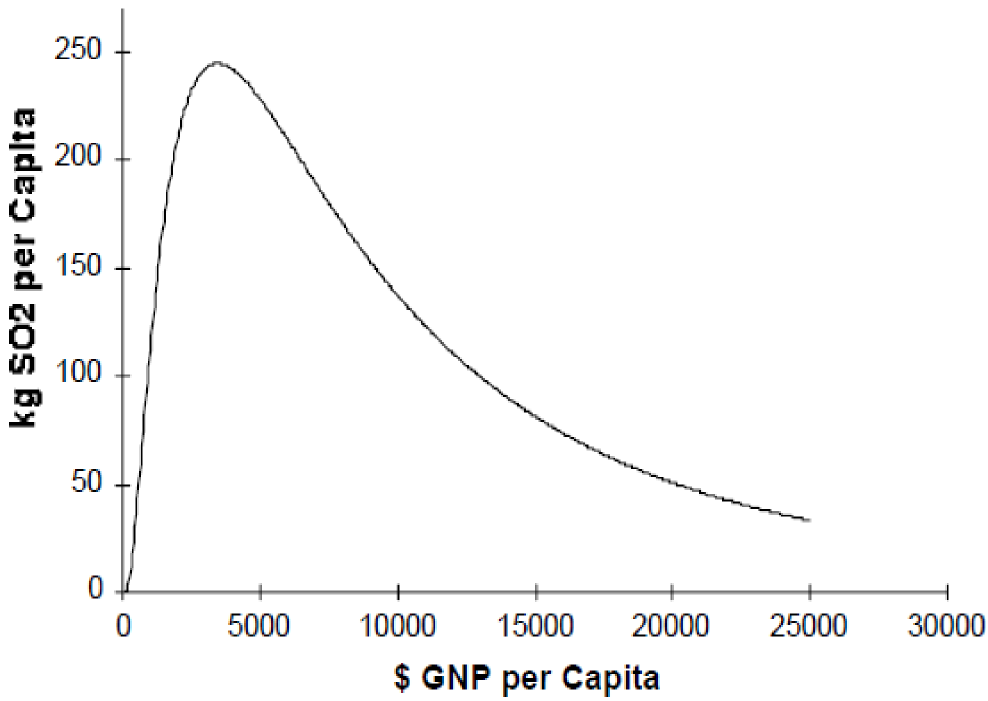
I. Introduction

Since historical times, the pursuit of higher growth and economic prosperity has remained an important objective of government policies. However, the attainment of higher growth entails the use of natural resources (e.g. energy resources), leaving in its wake some debilitating effects on the environment. Hence achieving sustainable development – continuing improvements in the present quality of life at lower intensity of resource use without compromising future generations – has continued to received worldwide attention than ever, especially with global warming, climate change and other environmental problems becoming more and more serious. In particular, an urgent subject for policy makers charged with environmental policies is to understand and predict how the environmental quality will evolve over time. One hypothesis that is extensively used in Environmental Economics literature to empirically model the growth-environmental degradation trajectory is the so called Environmental Kuznets Curve (EKC for short). The EKC hypothesis postulates an inverted U-shaped relationship between environmental degradation and income per capita[4]. In other words, environmental degradation is expected to increase with income up to a certain threshold beyond which environmental quality will be enhanced by higher income per capita. A typical EKC is as displayed in Figure 1 below.

The logic of the EKC is intuitively appealing: in the early stages of industrialization, pollution grows more rapidly because high priority is given to increasing material output, and people are more interested in income than environment. The rapid growth inevitably leads to higher utilization of natural resources and thus higher emissions of pollutants, which in turn worsens the environmental conditions. However, at the later stage of industrialization and as income increases, the willingness to pay for a clean environment increases by a greater proportion than income, regulatory institutions become more effective for the environment and pollution levels starts to fall (Kijima, Nishide & Ohyama, 2010). This tends to suggest that instead of being a threat to the environment, economic growth could be compatible with environmental improvements in the long run as countries could eventually "grow themselves" out of their environmental problems.

[4] The inverted U-shaped relationship derives its name from the work of Kuznets (1955) who postulated a similar relationship between income inequality and economic development.

Figure 1: The EKC for Sulfur Emissions (SO_2)



Source: Panayotou (1993), Stern, *et al.* (1996)

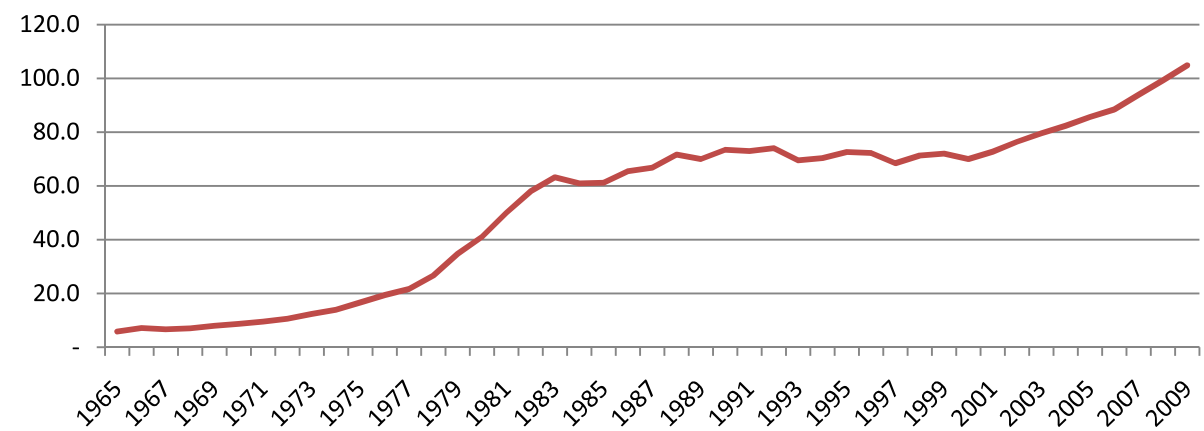
A sizeable number of empirical studies on the EKC hypothesis exist (e.g. Akbostanci, Turut-Asik & Tunc, 2009; Diao, Zeng, Tam & Tam, 2009, Re & Richard,2010)[5]. However, in contrast to the vast empirical literature on the EKC, there are only a few studies that have focused on developing countries. Specific country studies, as against cross country studies, also tend to be few. Based on an alternative growth model, De Bruyn et al. (1998) estimated the individual EKC for four countries, namely, the Netherlands, UK, USA and Western Germany, using data from 1960 to 1993. Their analysis reveal that the EKC is not generally fit for all the countries: each country has its own technological, structural, energy price and economic growth path, so the emission situation should not be the same. Hence, it has been argued that only single country studies can really provide an answer to the existence of EKC.

In the light of the above, the present study contributes to the raging debate on EKC by seeking to investigate the existence and policy-relevance of the EKC for Nigeria. Nigeria presents a unique

[5] A good survey of the empirical studies on the ECK hypothesis could be found in Dinda (2004)

case study given its near total dependence on oil exploration to drive its growth process and the consequent environmental cost. Evidence from CBN (2008) shows that between 1973 and 2008, the share of crude oil and gas production in total GDP range between 21.1 and 37.5%, whereas for the same period, output from the service sector (which is regarded as less polluting) has been between 6.7 and 16.2%. Environmental concerns (such as reducing gas flaring) has continue to remain a major challenge and an important component of environmental policies in Nigeria for the past decade. What is more? Out of 207 countries sampled in 2004, Nigeria ranks as the 36th higher carbon emitters in the world (Marland, et al, 2004). Presently, Nigeria's contribution to $C0_2$ emission is quite high; $C0_2$ emission rose steadily from mere 5.9 million tons in 1965 to 104.8 million tons in 2009 (see Figure 2). Such worsening trends is a clear indication that environmental quality in Nigeria will remain an increasing concern both in the present and the future and therefore requires adequate consideration from policy makers.

Figure 2: Trend of $C0_2$ emmision in Nigeria (million tonnes)



Source: World Development Indicator, CD-ROM (2010).

Following Diao, Zeng, Tam & Tam(2009), this study investigates the EKC hypothesis for Nigeria over the period of 1960 to 2008. Instead of using a quadratic model, we estimate a cubic parametric model using real per capita GDP as a measure of income and $C0_2$ emissions to proxy environmental degradation. The choice of a cubic model instead of the traditional quadratic model is to enable us capture the possible functional forms beyond the inverted U-shape. To overcome omitted variable bias, we include the shares of manufacturing, agriculture and service sectors in GDP as well as trade openness (proxy by foreign trade) in the estimation. Furthermore, the paper utilizes the bounds test approach to cointegration developed by Pesaran and Shin (1999) and latter extended by Pesaran, et al. (2001). Overall, the existence of an EKC for Nigeria is not supported by our data. Rather, our results show that the relationship between income and environmental degradation in Nigeria follows an inverse *N*-shape as against an inverted U-shaped curve. The policy implication of this findings and why Nigeria should look beyond the EKC are discussed in the paper.

The structure of this paper is clear. Section 2 presents a review of the literature. In Section 3, the econometric methodology adopted for the study is discussed. The empirical results are reported in Section 4 with policy implication discussed in section 5. Section 6 offers concluding remarks and agenda for further research.

2. **Overview of the EKC-Literature**

Since the beginning of the 1990s, empirical research on the validity, relevance and measurement of the Environmental Kuznets Curve (EKC) has been prolific. This follows the seminal works of Grossman & Krueger (1991), Shafik & Bandypadhyay (1992), Panayotou (1993) and Selden & Song (1994). Grossman & Krueger first pointed out the inverted U-shaped relationship between environmental pollutants and per capita income in their study of the environmental impacts of the North American Free Trade Agreement (NAFTA). This U-shaped relationship was latter coined by Panayotou as the Environment Kuznets Curve. The curve is so named because it mirrors a similar relationship between income inequality and per capita income first hypothesized by Kuznets (1955).

Empirical evidence on the EKC hypothesis is at best mixed. While some studies find a linear relationship between environmental degradation and growth (e.g. Shafik & Bandyopadhyay, 1992; Shafik, 1994; De Bruyn, et al, 1998; Akbostanci, et al, 2009 and Fodha & Zaughdoud, 2010), others have confirmed an inverted U-shaped relationship in line with the EKC hypothesis (e.g. Grossman & Krueger, 1995; Lindmark, 2002; Galeolti, et al, 2006, Jalil & Mahmud, 2009). Yet others have found an N-shaped relationship (Friedl & Getzner, 2003; Martinez-Zarzoso & Bengochea-Maranco, 2004) which suggests that any delinking of environmental degradation from economic growth is only temporary (He & Richard, 2010). The results confirming the existence of an EKC-type relationship lead some of the authors to conclude that countries could simply "grow out of environmental problems" (Shafik & Bandyopadhyay, 1992) or that "faster growth could serve as part of the *solution* to the worldwide emissions dilemma" (Holtz-Eakin & Selden, 1992:3) or more cautiously that "economic growth could be compatible with environmental improvements if appropriate policy responses were taken" (Stagl, 1999).

However, great discrepancies about the turning point at which the delinking occurs exist among authors who find an inverted U-shaped EKC (He & Richard, 2010). Turning points ranging from $8,000 to $ 60,000 have been reported by different authors. While Cole (2004) found a turning point of $62,700 with a log-linear model and at $25,100 with levels data for the U.S., Wang, et al, (1998) had earlier obtained a turning point for the U.S. at $23,000 for assessed risk of hazardous exposure. For ambient concentrations of SO_2, Grossman & Krueger (1995) estimate the turning point to lie between $4000 and $5000 per capita (in 1985 dollars). Such discrepancies have been attributed to several factors such as the functional form of the model used, the inclusion of additional control variables aside the income variables, among others. For instance, Suri & Chapman (1998), using a simple panel data model, estimated the turning the turning point for energy consumption to lie at $ 55,000 – a level that they described as unrealistic for any country to attain in the nearest future. In their second model used to analyzed the impact of international trade on energy consumption, the turning point was substantially raised to $224,000 when the trade variable was introduced.

In what ways can economic growth leads to improved environmental quality in the long run? The answer to this question has generated several intuitive and appealing explanations in the environmental literature. More formally, Grossman & Krueger(1991) explain that economic growth could affects the environment through three different channels: *scale effect, composition effect* and *technique effect.* The scale effect occurs as pollution increases with the size of the economy. The explanation is that even if the structure of the economy and technology does not change, an increase in the scale of economic activity (production) will lead to increase in pollution and environmental degradation. The composition effect, on the other hand, refers to the change in the production structure of an economy from agriculture based to industry and service based which results in the re-allocation of resources. In other words, in the early stages of development process, pollution rises as economic structure changes from agriculture to more resource intensive heavy manufacturing industries. Finally, the technique effect captures improvements in the technique of production and adaptation of more cleaner technologies and hence, a reduction in pollution. Depending upon the relative magnitude of the three effects, a monotonous, a U-shape, an inverted U-shape or in fact any pattern between income and environmental quality may emerged (Wagner, 2008). Akbostanci, et al. (2009) explains that while the *scale effect* is expected to dominate the other effects on the rising range of the EKC, *composition* and *technique effects* are expected to dominate the *scale effect* at the declining range.

In Panayotou's (1993) view, at higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures would ultimately lead to a leveling off and gradual decline in environmental degradation. The common assumption is that poor people have little demand for cleaner environment and are constrained by their present consumption needs to degrade their environment. Given this, it is assumed that as the society becomes richer, the income elasticity of its members for a more healthy and sustainable environment will rise and in which case the government may be called upon to impose more stringent environmental controls. This tends to suggest that cleaner environment is a luxury good. However, this proposed mechanism of getting richer as a simulation for people to look for environmental improvements has been seriously criticized in the literature[6].

Beyond growth, some authors have also likened environmental quality to other factors such as trade openness. The impact of trade on the environment is mixed and depends on the level of economic development stage of a country. On one hand, it has been argued that environmental quality could deteriorate through the scale effect as increasing trade volume (especially export) raises the size of the economy , which increases pollution. On the other hand it has been argued that trade can lead to an improvement in environmental quality through the composition and/or technique effect: as trade raises income, environmental protection laws and regulation is tightened that spurs pollution reducing innovation (Ciegis et al. 2007). The pollution from the production of certain pollution intensive goods declines in one country as it increases in another country through international trade. The composition effect of trade is attributed to two related hypothesis: *Displacement hypothesis* (which asserts that trade liberalization or openness is

[6] An excellent critic of this proposition could be found in Stagl (1999)

associated with increasing pollution emissions especially in developing countries due to the rapid growth of pollution-intensive industries as developed countries enforce strict environmental regulations) and *Pollution Haven Hypothesis* (which refers to the possibility that multinational firms, particularly those that engaged in highly polluting activities, relocate to developing countries with less restrictive environmental standards) . In view of the above, studies like Grossman & Krueger (1995), Halicioglu (2009), Ang(2009) and Jalil & Mahmud (2009) included the trade variable in their EKC estimation. A positive link between foreign trade and $C0_2$ emissions has been found by Ang (2009) for China and Machado (2000) for Brazil.

3. Methodology

3.1 *The Model*

The choice of an appropriate indicator of environmental degradation is problematic. This stems from the qualitative problems encountered in measuring environmental quality (Akbostanci, et al., 2009) as well as data availability. Hence different indicators have been employed in empirical literature on EKC. Traditional models of the EKC include an indicator of environmental degradation (such as per capita $C0_2$ emissions, $S0_2$, $N0_x$, etc.) as a function of the levels and squares of per capita income. However, recent studies have shown that these models suffer from omitted variable bias as the addition of more explanatory variables also bear significant effect on environmental quality. As argued by Harbaugh, et al. (2002), there is not much theoretical guidance for the correct specification of the EKC. This means that the EKC is merely an empirical phenomena. In its general format, the standard EKC hypothesis can be given as follows:

$$C_t = \delta_0 + \beta_1 y_t + \beta_2 y_t^2 + \beta_3 y_t^3 + \tau Z_t + \varepsilon_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where C_t is per capita $C0_2$ emissions (used as a proxy for environmental degradation)[7], y_t is real per capita GDP, and Z_t is a vector of other explanatory variables that may influence environmental degradation. For various reasons such as data availability and/or small size, most studies (e.g. Akbostanci, et al., 2009; Fodha & Zaghdouf, 2010) normally omit the vector Z_t

[7] Some authors have argued that $C0_2$ emissions are global pollutants and therefore may not be appropriate for country-specific studies. However, our choice of CO_2 emissions is guided by data availability since time series data on local pollutants like SO_2 are not readily available for Nigeria. Most country specific studies (e.g. He & Richard, 2010; Fodha & Zaghdoud, 2010) have also used $C0_2$ emissions per capita in their modeling of the EKC .

which as observed by He & Richard (2010) may lead to biased and inconsistent inferences and parameter estimation. In view of the above, this study considers the inclusion of other key explanatory variables in Model 1. Abstracting from the literature, the model used in this study is of the form:

$$C_t = \delta_0 + \beta_1 y_t + \beta_2 y_t^2 + \beta_3 y_t^3 + + \beta_4 M_t + \beta_5 A_t + \beta_6 S_t + \beta_7 T_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots..(2)$$

Where T_t is trade openness ratio (which is used as a proxy for foreign trade), M_t , A_t and S_t represent the shares of manufacturing, agric and services sectors in GDP respectively. Other variables are as defined earlier.

Different values for the coefficient of the income term allows us to test the various functional forms of the environmental degradation-economic growth relationship: $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$ indicate an *N*-shaped relationship ; $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$ reveals an inverse *N*-shaped relationship; $\beta_1 > 0,$ and $\beta_2 = \beta_3 = 0$ indicate a monotonically increasing linear relationship; $\beta_1 > 0, \beta_2 > 0$ and $\beta_3 = 0$ connote a U-shaped relationship; $\beta_1 > 0, \beta_2 < 0,$ and $\beta_3 = 0$ depict an inverted U-shaped relationship, suggesting the EKC hypothesis. The maximum point or turning point $(\dot{\tau})$ of the EKC function is achieved at the coefficient on *y* over twice the absolute value of the coefficient on y_2:

$$\dot{\tau} = \left|\frac{\beta_1}{2\beta_2}\right| \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

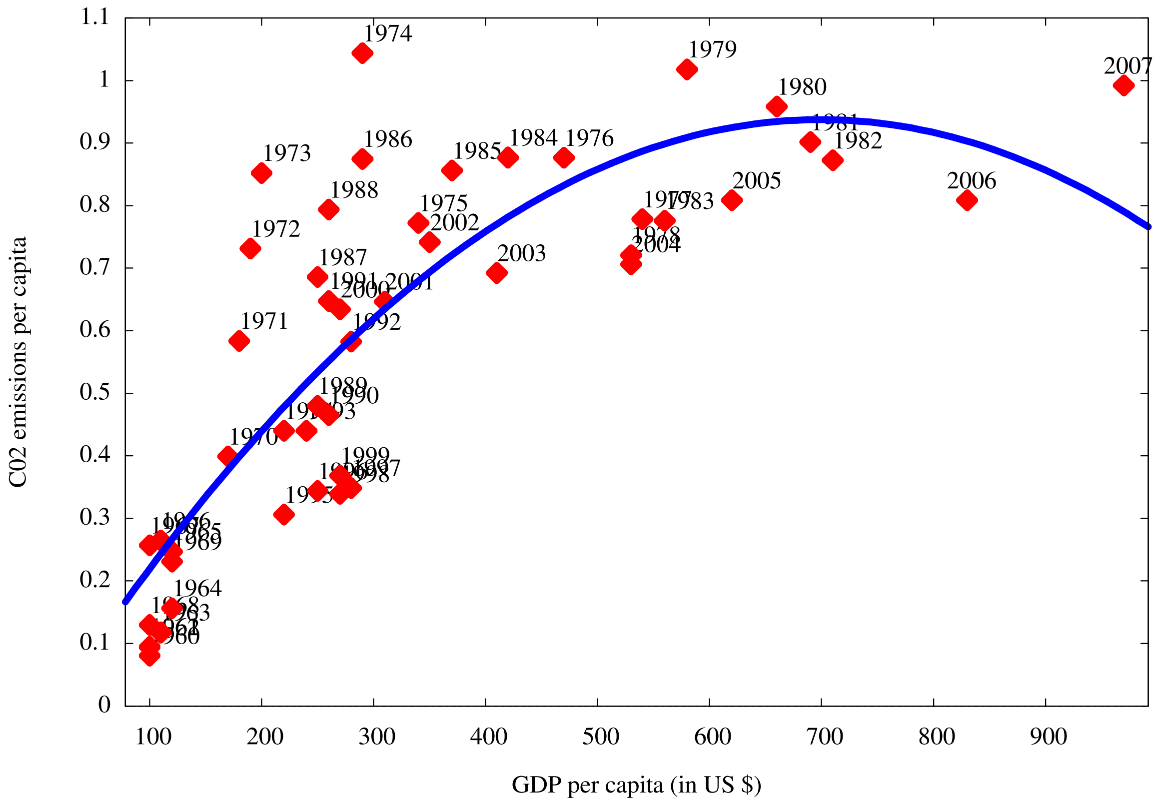
The expected sign and plausibility of including additional variables in model 2 are the following. Given that most developing countries tends to have dirty industries with heavy share of pollutants (Grossman & Krueger, 1995; Halicioglu, 2009) couple with lower environmental protection laws, we expect the sign of the trade variable to be positive in Nigeria. The inclusion of M_t , A_t and S_t is to capture the output mix in the Nigerian economy. As the economy moves from agricultural based to industrial based, pollution is expected to rise, hence the coefficient of the variables (M_t and A_t) are expected to be positive whereas it may be negative in the case of S_t as the latter is not generally considered as pollution intensive.

3.2 Data Requirements

To carry out the estimation, the paper employs annual time series data for Nigeria from 1960 to 2008. $C0_2$ emissions (measured in metric tons per capita) were sourced from World Development Indicators (WDI),CD-ROM (2010). Data on real GDP per capita (measured in 2005 constant U.S. $) and trade openness (in 2005 constant prices) were extracted from the Penn World Table while the shares of manufacturing, agric and services in GDP were sourced from CBN Statistical Bulletin (2008). The share of manufacturing in GDP composed of three major component: oil refining, cement and other manufacturing. Agric includes output from crop production, livestock, forestry and fishing, while services include transportation, communication and other utilities.

Table A1(at the appendix) displays the descriptive summary statistics for all the variables used in this study. As shown in the table, the mean share of agriculture in Nigeria's GDP is quite high (71,739.39) compared to that of the manufacturing(9272.022) and services sector (25,339.41). This tends to suggest that Nigeria's production structure may be pollution intensive. However normality could not be established for most of the variables (except Co2 per capita and the share of manufacturing in GDP) as revealed by the JB statistic. Figure 3 presents a scatter plots of a fitted quadratic relationship between environmental degradation variable(CO2 emissions) and income (GDP per capita) in Nigeria. It seems clear from the figure that there is a strong support for the EKC hypothesis in Nigeria. However, casual analysis of this nature may be highly misleading and thus the need for proper estimation to validate the hypothesized relationship .

Figure 3 : CO 2 emissions versus GDP per capita (with quadratic fit)



3.2 Model Estimation Strategy

The EKC hypothesis is intended to represent a long-term relationship between environmental quality and economic growth. In the last two decades, a number of techniques such as the Engle & Granger (1987) and the full information maximum likelihood method of Johansen (1996) have been employed to test the existence of long run relationship among variables. Recently, a relatively new technique – the autoregressive distributed lag model (ARDL) – has become more popular among researchers. The ARDL approach to cointegration, also known as the bounds testing approach, was developed by Pesaran and Shin (1999) and latter extended by Pesaran, *et al.,* (2001). The statistic underlying the procedure is the Wald or *F*-statistic in a generalized Dickey-Fuller type regression, which is used to test the significance of the variables under consideration in a conditional unrestricted equilibrium correction model (UECM). The ARDL approach has several advantages over other traditional techniques such as the ones mentioned above.

The first main advantage of this approach is that it is more flexible and can be applied irrespective of whether the underlying regressors are purely *I* (0) , *I*(I) , or mutually cointegrated. Thus, because the bounds test does not depend on pretesting the order of integration of the variables, it eliminates the uncertainty associated with pretesting the order of cointegration (Narayan & Narayan, 2004). In essence, the approach does not require all the variables in the system to be of equal order of integration[8]. Also the approach can be applied to studies that employ relatively small sample size, such as the present study. As demonstrated by Pesaran & Shin (1999), the small sample properties of the ARDL approach are far superior to that of the Johansen and Juselius'(1990) cointegration technique[9]. Another important advantage of this procedure is that the estimation is possible even when some of the explanatory variables are endogenous. It also allows for the estimation of long-run and short-run parameters of the variables under the same framework.

Basically, bounds test approach involves two steps. The first step is to investigate the existence of long-run relationship among the included variables. The ARDL framework for this study are formulated as follows:

$$\Delta C_t = \delta_0 + \pi_1 C_{t-1} + \pi_2 y_{t-1} + \pi_3 y_{t-1}^2 + \pi_4 y_{t-1}^3 + \pi_5 M_{t-1} + \pi_5 A_{t-1} + \pi_6 S_{t-1} + \pi_7 T_{t-1} + \sum_{t=1}^{a} \sigma_i \Delta C_{t-i} + \sum_{t=0}^{b} \alpha_i \Delta y_{t-i} + \sum_{t=0}^{c} \emptyset_i \Delta y_{t-i}^2 + \sum_{t=0}^{d} \gamma_i \Delta y_{t-i}^3 + \sum_{t=0}^{e} \partial_i \Delta M_{t-i} + \sum_{t=0}^{f} \lambda_i \Delta A_{t-i} + \sum_{t=0}^{g} \varpi_i \Delta S_{t-i} + \sum_{t=0}^{h} \varpi_i \Delta T_{t-i} + \varepsilon_t \qquad (4)$$

[8] The major drawback of the ARDL approach is that it fails to provide robust results if the order of integration is greater than one , e.g. *I*(2).

[9] The Johansen & Juselius's Maximum Likelihood technique is based on a VAR systems of equations which is fairly data intensive and there is substantial loss of degree of freedom, which could render the validity of most of the results based on relatively small sample dubious. These limitations do not apply to the ARDL methodology (see. Romill & Song., 2001)

Where δ_0 is the drift component and Δ is the first difference operator. Here the π_i denote the long-run multipliers while the terms with summation sings are used to model the short-run dynamic structure. Appropriate lag length is selected based on the Scawrtz-Bayesian criteria (SBC). The test procedure is based on the *F*-test or Wald statistics. As shown by Narayan & Smyth (2004), this is carried out via the exclusion of the lagged level variables in the above equation. It follows then that the test for the absence of any level relationship between environmental degradation (captured by per capita $C0_2$ emissions, C_t) and income entails the test of the null hypothesis ($H_0: \pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = \pi_6 = \pi_7 = 0$) against the alternative ($H_1: \pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq \pi_5 \neq \pi_6 \neq \pi_7 \neq 0$). The test which normalize on C is denoted by $F_C(C/y, y^2, y^3, M, A, S, T)$.

The computed *F*-statistic is then compared with two sets of critical values provided by Pesaran, *et al.* (2001). One set assumes that all variables are *I*(0) and the other assumes they are *I*(1). If the computed *F*-statistic exceeds the upper critical value, then the null hypothesis of no cointegration will be rejected. If it is below the lower bound, then the null hypothesis of no cointegration cannot be rejected. However, it falls into the bounds, the test is inconclusive. Recently, Narayan (2004) has argued that the critical bounds provided by Pesaran, *et al.* (2001) are inappropriate in small sample size[10] and has regenerates new sets of critical values for samples ranging from 30 to 80 observations. To this end, given the relatively small sample size in this study (49 observations), appropriate critical values will also be extracted from the latter source.

Once cointegration is established, the second stage involve the estimation of the following conditional ARDL (a, b, c, d, e, f, u, v) long-run model:

$$C_t = \delta_0 + \sum_{t=1}^{a} \sigma_i C_{t-i} + \sum_{t=0}^{b} \alpha_i y_{t-i} + \sum_{t=0}^{c} \emptyset_i y_{t-i}^2 + \sum_{t=0}^{d} \gamma_i y_{t-i}^3 + \sum_{t=0}^{e} \partial_i M_{t-i} + \sum_{t=0}^{f} \lambda_i A_{t-i} + \sum_{t=0}^{u} \varpi_i S_{t-i} + \sum_{t=0}^{v} \vartheta_i T_{t-i} + \varepsilon_t \qquad \dots\dots\dots\dots\dots (5)$$

Where all variables are as previously defined. Estimation of equations (5) involve the selection of the optimal lag orders of the ARDL (a, b, c, d, e, f, u, v). Finally, short-run dynamic

[10] The critical values reported in Pesaran and Shin (1999) and Pesaran, et al (2001) are based on sample sizes of 500 and 1000 observations respectively.

parameters of the model associated with the long-run estimates can be obtained by estimating the following error correction model:

$$\Delta C_t = \delta_0 + \sum_{t=1}^{a} \sigma_i \, \Delta C_{t-i} + \sum_{t=0}^{b} \alpha_i \, \Delta y_{t-i} + \sum_{t=0}^{c} \emptyset_i \, \Delta y_{t-i}^2 + \sum_{t=0}^{d} \gamma_i \, \Delta y_{t-i}^3 + \sum_{t=0}^{e} \partial_i \, \Delta M_{t-i} + \sum_{t=0}^{f} \lambda_i \, \Delta A_{t-i} + \sum_{t=0}^{u} \varpi_i \, \Delta S_{t-i} + \sum_{t=0}^{u} \vartheta_i \, \Delta T_{t-i} + \eta ect_{t-1} + \varepsilon_t \quad \ldots (8)$$

Where ect is the error correction term (representing the residual of the co-integrating equation) and η represents its coefficient. The error correction coefficient shows how quickly the variables converge to equilibrium and should be statistically significant and negative.

Establishing a long-run relationship among the variables under consideration is necessary but not sufficient, since the existence of cointegration does not suggest that the estimated coefficients are stable. Thus, to ensure the goodness of fit of the model, stability tests of the estimated parameters are necessary. To this end the study employed stability tests proposed by Brown, *et al.,* (1975) known as the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ). The CUSUM and CUSUMSQ statistics are updated recursively and plotted against the break points of the model. If the plots of CUSUM and CUSUMSQ statistics stay within the critical bounds of 5% level of significance, the null hypothesis that all the coefficients in the given regression are stable cannot be rejected.

4. Empirical Results

4.1 Unit Root Test

Because the bounds test is based on the assumption that the variables are either *I*(0) or *I*(I), the implementation of unit root tests in the ARDL procedure is still necessary to ensure that none of the variables is *I*(2) or beyond. In view of this, we employ the conventional Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1974) and Phillips-Perron test (Phillips and Perron, 1988). The results are displayed in Table 1. Both test statistics indicate that while the share of agriculture and services in GDP are stationary at levels, the rest of the variables become stationary at first difference. This implies that the null hypothesis of non-stationarity for all the variables is rejected. Most importantly, the results show that we can confidently apply the ARDL methodology to our model.

Table 1:Sumarry of Unit Root Test Results

	ADF		PP		
Variable	Level	1st Difference	Level	1st Difference	Conclusion
C	-2.7146(0)	-7.462(0)***	-2.1264(1)	-7.4604(1)***	*I*(1)
y	-1.0390(1)	-4.6135(0)***	-2.2232(2)	-4.5879(2)***	*I*(1)
y^2	0.9544(0)	-4.5777(0)***	0.2264(3)	-4.7685(0)***	*I*(1)
y^3	1.3717(0)	-4.8678(0)***	0.7717(3)	-4.8959(1)***	*I*(1)
M	0.5384(0)	-6.0222(1)***	0.6171(4)	-5.3137(6)***	*I*(1)
A	2.8028(0)*	-5.6905(0)***	3.3805(5)**	-5.6997(2)***	*I*(0)
S	5.0331(0)***	-4.3285(0)***	5.4779(2)***	-4.5523(4)***	*I*(0)
T	-2.4032(0)	-7.1416(0)***	-2.4032(0)	-7.1684(2)***	*I*(1)

*Note:. ***,**,* denotes significance at the 1%, 5%, 10% levels respectively. The values in bracket for the ADF test indicate the optimal lag selected by the SIC within a maximum lag of 10. For the PP test, the spectral estimation is based on the Bartlett Kernel Method and the values in bracket indicate the bandwidth selection using the Newey-West approach. Both estimations assume a constant term for the error term.*

4.2 Bounds Cointegration Test Results

The ARDL test for the presence of long-run relationships in Model 2 are reported in Table 2. Since this study employs annual data, we follow the tradition of Narayan & Smyth (2005) and set the maximum lags in the ARDL models to 2 ($i_{max} = 2$). The estimated models presented in Table 2 are based on minimizing the Schwartz Bayesian Criterion. The bounds F-test for cointegration test yields evidence of a long-run relationship between environmental degradation and its determinants. The computed F statistic, $F_C(.) = 8.74$, is greater than the upper bound of the 1% critical values resulting in the rejection of the null hypothesis of no long-run relationship between the examined variables. This evidence rules out the possibility of estimated relationship being spurious.

Table 2: Bounds Test Results for Cointegration Relationship[11]

Critical bounds value of the *F*-statistic

K	*1% level*		*5% level*		*10% level*	
	I(0)	*I*(1)	*I*(0)	*I*(1)	*I*(0)	*I*(1)
7[PS]	2.96	4.26	2.32	3.50	2.03	3.13
7[N]	3.49	5.15	2.56	3.90	2.21	3.42
Calculated *F*-statistics	$F_C(C/y, y^2, y^3, M, A, S, T)$= 8.74023***					

Note: *The lag structure was selected based on the Schwartz Criterion. K is the number of regressors. [PS] Pesaran, et al (2001:300), Table CI(iii), Case III: Unrestricted intercept and no trend, [N]Narayan (2004), Appendix: Case III for N=50. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively.*

Table 3 displays the estimated long-run relationship between environmental degradation and its determinants. All the long-run co-efficient in the model are statistically significant at different levels, except the share of agriculture in GDP. The results reveal that there is an inverse *N*-shaped relationship between environmental degradation and per capita income in Nigeria. This conclusion is based on the signs of the income variables ($\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$). This implies that any beneficial effects of economic growth on environmental degradation in Nigeria is merely transitory. Any observed reduction in environmental quality will be followed by an increasing environmental degradation in the long run. Thus our empirical findings do not support the hypothesis of an inverted U-shaped EKC for environmental degradation in Nigeria. This result is consistent with the findings of Fodha and Zaghdoud (2010) for Tunisia using SO_2 emissions.

[11] *As a sensitivity check, we also carried out cointegration test using the conventional Johansen's Maximum Likelihood Method. The conclusion did not change: Trace and Max. Eigen Statistic of the Johansen tests report 3 and 5 co-integrating equations in Model 2 respectively. These results are not shown here to conserve space.*

Table 3: Estimated long-run coefficients for the ARDL (0,0,0,0,0,0,1,0) Model

Dependent variable: Co2 emissions per Capita

Variable	*Coefficient*	*T-Ratio*	*P-Value*
Constant	4.3132	(1.662)	[0.1045]
y	-0.0089	(-1.915)	[0.0628]
y2	5.759e-06	(2.118)	[0.0406]
y3	-1.1109e-09	(-2.179)	[0.0355]
M	3.884e-05	(3.020)	[0.0044]
A	-8.557e-07	(-0.4929)	[0.6242]
S	-7.9867e-06	(-2.127)	[0.0398]
T	0.0058	(2.137)	[0.0390]
Turning point ($\dot{\tau}$)	\$ 77.27		

Diagnostic Check

Adjusted *R*-square *:* 0.6292 | ***F*-Ratio**: 12.153 (4.07e-08)

Log-Likelihood: 20.9570 | **RESET (squares only)** *:* 9.4756 (0.00046)

CHOW(1973): 2.6127 (0.02604) | **Normality:** chi-square(2): 7.9711(0.0185)

ARCH (2): 10.1721(0.00618)

Note*: Values in bracket for the relevant test statistic indicate the P-values. The ARDL model was selected based on SIC.*

Further, the computed turning point is approximately equals to \$ 77.27 (constant 2005 prices) which is obviously too low and lies outside our data set. The estimated coefficients of the share of manufacturing and service sectors in GDP are not only significant but also appear with the correct sign: manufacturing industries in Nigeria (especially oil and cement industries) are pollution intensive while the service sectors are not. However, the share of agriculture assumed a negative sign contrary to the theoretical expectation. Although the coefficient is not significant, it provides an indication that the production structure in Nigeria is not agricultural driven and hence its insignificant contribution to $C0_2$ emission. Also, trade openness significantly worsens environmental conditions in Nigeria. This suggests that the more open the Nigeria economy is the more her environmental conditions deteriorates. The above findings suggest that the *pollution haven* hypothesis holds for Nigeria. This findings is consistent with the results obtained by Ang (2009) for China.

Specification tests reported at the bottom of Table 3 suggest that the model is fairly well specified and robust for policy analysis (see the RESET and ARCH effects). The adjusted *R*-square shows that about 62.9 % variations in environmental degradation is explained by the included regressors. Also the data rejects the null hypothesis of structural break at observation 1973 which corresponds to the oil price shock. This suggest that the 1973 oil price shock has no effect on the relationship between environmental degradation and income in Nigeria. This result is contrary to the findings of He and Richard (2010) that the 1973 oil price shock was significant in the income-emission relationship for Canada.

The short-run results are presented in Table 4. The coefficient of the loading factor (error correction term) is correctly signed and statistically significant at 1% confidence level. It implies that an error correction mechanism exists so that the deviation from long-run equilibrium has a significant effect on pollution emission growth in Nigeria. The value of -0.4259 implies that about 42.59% of the disequilibria in environmental degradation ($C0_2$ emissions per capita) of the previous year's shock adjust back to the long-run equilibrium in the current period. The signs of the income terms provide very weak evidence for EKC in the short run. This is viewed as such since the sign of the cubed-income term (even though not significant) is not zero. Besides the EKC is hypothesized as a long-run phenomena rather than a short-run situation. Overall, the result indicates that economic growth contributes significantly to $C0_2$ emissions per capita in Nigeria both in the long-run and the short-run, without any strong evidence that emissions will decline in the long-run as growth is intensified. The output variables are also significant in explaining short-run changes in $C0_2$ emissions per-capita in Nigeria. Specifically, while the industrial sector (*M*) and service sector *(S)* have both long-run and short-run impact on environmental degradation, agric. sector (its second lag) positively contributes to environmental degradation in the short run. The impact of the trade variable is not significant in the short-run.

Table 4: Parsimonious Error Correction Representation for the Selected ARDL Model

Dependent Variable is $C0_2$ emissions per capita.			
Variable	*Coefficient*	*T-Ratio*	*P-value*
Constant	0.02421	1. 328	0.1931
Δy	0.00065	4.584	6.25e-05
$\Delta y2$ (-2)	1.5184e-07	3.208	0.0030
$\Delta y3$ (-1)	-1.91426e-011	-1.191	0.2423
ΔM	7.39337e-05	3.692	0.0008
ΔA	-1.2525e-05	-3.520	0.0013
$\Delta A(-1)$	4.39703e-06	1.593	0.1207
$\Delta A(-2)$	1.08402e-05	2.733	0.0100
$\Delta S(-1)$	-1.53697e-05	-2.963	0.0056
$\Delta S(-2)$	-1.59354e-05	-3.115	0.0038
$\Delta T(-1)$	-0.003283	-1.545	0.1320
$ECT(-1)$	-0.425942	-3.700	0.0008

Diagnostic Check

Adjusted R-square: 0.3863	F-Ratio: 3.5188(0.0025)
Log-likelihood: 46.6778	Durbin-Watson: 2.0078
Chow(1973): 0.5854 (0.8092)	ARCH(2): 1.7706 (0.41256)
Normality(chi-square, 2) 5.4887 (0.0643)	RESET(squares only): 0.82315 (0.0508)

***Note**: Values in bracket for the relevant test statistic indicate the P-values.*

As shown in the bottom of Table 4, the short-run model also passes through a series of standard diagnostic tests such as functional form specification test, stability, normality and heteroscedasticity. The Durbin-watson statistic of 2.008 rules out any evidence of autocorrelation in model. The F-test reveals that the overall estimation is significant. However, the adjusted R-square shows that the model may not provide a good fit as only 38.6% short-run variations in environmental degradation is attributed to the included variables.

The stability analysis of the model is carried out through the CUSUM and CUSUMSQ techniques. As can be seen from Figures 2 and 3 (at appendix), the plots of the CUSUM and CUSUMSQ statistics are well within the 5% critical bound (represented by the two straight lines). This implies that all the coefficients in the parsimonious ECM model are stable.

5. Policy Implications

The findings of this study bears several policy implications for Nigeria. Economic growth is significantly associated with increased environmental degradation in Nigeria both in the short run and the long run. The fact that Nigeria's case is exemplified by an inverse *N*-shape rather than the hypothesized inverted U-shaped income-emission trajectory implies that any decision to overlook environmental protection in Nigeria by reckoning on an increasing income levels to solve its environmental pollution could results in devastating consequences for the nation. This simply implies that Nigeria cannot "grow itself" out of its environmental problems, hence the need to look beyond the EKC hypothesis.

What is more? The finding of a turning point at $ 77.27 which lies far below our data range shows that the EKC serves as a dangerous guide to environmental policy making in Nigeria. Taking the EKC at its face value could send dangerous signal that economic growth should be the main priority of governments, with the protection of the environment as secondary that could best be left for the future. Nigerian policy makers need also be mindful of the literature on environmental sustainability which strongly suggests that social welfare rather than income per capita should be the primary focus of government policies (see Gowdy, 2004 and 2005). Studies have shown that environmental degradation, including air and noise pollutions reduces life satisfaction (see Di Tella and MacCulloch, 2008). At another level, there is also growing evidence that environmental degradation generates negative environmental externalities for the economy, for instance through a reduction in health human capital and hence, productivity in the long-run (Ang, 2008). More so, environmental damage caused by economic growth cannot be wholly reversible, hence a reduced environmental degradation in the long-run (if at all it occurs) may not imply that the initial environmental condition could be restored. Thus there is an urgent need for explicit policies to control environmental degradation in the country.

Viewed from the output effect, most environmental degradation in Nigeria stems from the manufacturing sector. This results is particularly revealing as the industry is dominated by oil refining activities and cement manufacturing which are chief sources of environmental pollution in Nigeria in recent times. This implies the need to strengthen environmental pollutions policies in Nigeria, especially with regards to gas flaring. Apart from targeting regulatory monitoring of the oil and gas sector, an alternative approach could be to move away from the command-and-control strategies towards a market oriented form of regulation as suggested by Chuku (2011). Also the use of pervasive informal regulations should also be considered. Several studies have shown that such approach is effective especially in developing economies (Dinda, 2004; Raymond, 2004).

The long-run significant of trade on per capita emissions further stress the need to keep environmental policies focused in order to stem the trade-induced- pollution-haven degradation in Nigeria. The unfettered trade liberalization policy should also be re-considered.

6. Conclusions, Limitations and agenda for further research

This paper explores the existence of an inverted long-run U-shaped income-environmental degradation hypothesis dubbed Environmental Kuznets Curve (EKC) for Nigeria over the period 1960 to 2008. To avoid the problem of omitted variable bias, we departed from some traditional literature by including (in addition to the level, square, and cubed of the income variables) other explanatory variables like foreign trade and the output mix: share of manufacturing , agriculture and service sectors in GDP. $C0_2$ per capita was used as a proxy for environmental degradation.

The ARDL bounds test approach to co-integration was applied in the study to check for the existence of long-run relationship between the included variables. The justification for adopting this approach was due to its superiority over other traditional techniques especially for small sample study like this. Before that, a test for unit root was carried out using the ADF and PP tests to ensure that the results are consistent with the bounds test procedure. The results of the unit root test show that none of the variables were integrated beyond order one. Overall, the bounds test provides evidence of long run cointegration among the included variables.

The estimated long-run relationship reveals that the Nigerian situation is exemplified by an inverted *N*-shaped income-environmental degradation trajectory with a turning point at $ 77.27. Thus, our data fails to provide evidence for the existence of EKC for Nigeria. Besides we observed that the computed turning point lies far below our data set which further contest the policy relevance and the existence of EKC for Nigeria. The paper also finds that, apart from economic growth, other variables like foreign trade, manufacturing industries (dominated by oil exploration) also contributes to long-run environmental pollution in Nigeria. This elicit the need for tighter environmental policies.

Overall, the findings of this study indicates that Nigeria should look beyond the EKC induced notion that economic growth is a panacea for environmental degradation. There is need for an urgent paradigm shift from the present means of promoting economic growth in which $C0_2$ emissions and other forms of environmental degradation are inherent. Even studies that have found support for EKC such as Grossman & Krueger (1995) were not unmindful that economic growth will not automatically lead to higher environmental quality but via strong pressure for stronger environmental policy. The quality of policy and institutions can significantly reduce environmental degradation even at low income levels and speed up improvements at higher income levels (see Panayotou, 1997). Apart from adopting stringent measures of environmental protection, ecological friendly means of economic growth must be pursued. In spite of being endowed with abundant alternative sources of energy that are relatively free from pollution emissions, evidence so far seems to suggest that Nigeria is yet to exploit them to drive its growth process.

Our results should however be interpreted with caution due to some of the limitations inherent in this study. First is the use of only emissions per capita to measure environmental degradation. $C0_2$ emissions have been pointed out as a global pollutant that cause problem on a global scale. The behavior of this single measure vis-à-vis economic growth may not be the same for a wide range of other air, noise and water pollutants. In other words, the findings of an EKC-typed relationship has been argued to be very sensitive to the type of pollutant measured which cannot be generalized for all emissions. Thus the use of a comprehensive measure of environmental degradation like the environmental sustainability index (ESI) could prove a useful exercise. Second, our results relied on the data obtained from Penn World Trade Table, thus a different set of data could produce different results. Further study should also consider the inclusion of other variables like electricity consumption, urbanization, automobile and generator use as well as crude oil prices in the estimation. There is much evidence in the literature that these variables also contributes to worsening environmental concerns in most developing countries (see Lean and Smyth, 2010). Of greater concern, casual evidence appears to suggest that increased prevalence of automobiles and heavy trucks in most cities in Nigeria accompanied with increased urbanization and poor supply of electricity across the country, which result in intense used of self-generating power, has exacerbated environmental pollution in the country.

APPENDIX

Figure 2: CUSUM plot with 95% confidence band

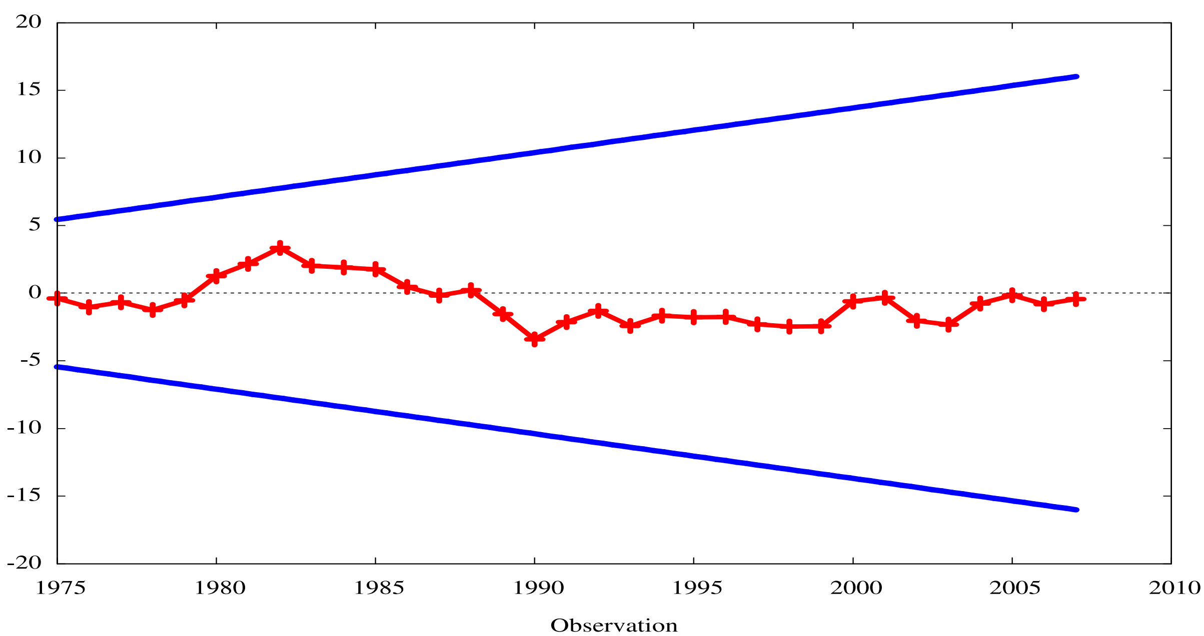


Figure 3 : CUSUMSQ plot with 95% confidence band

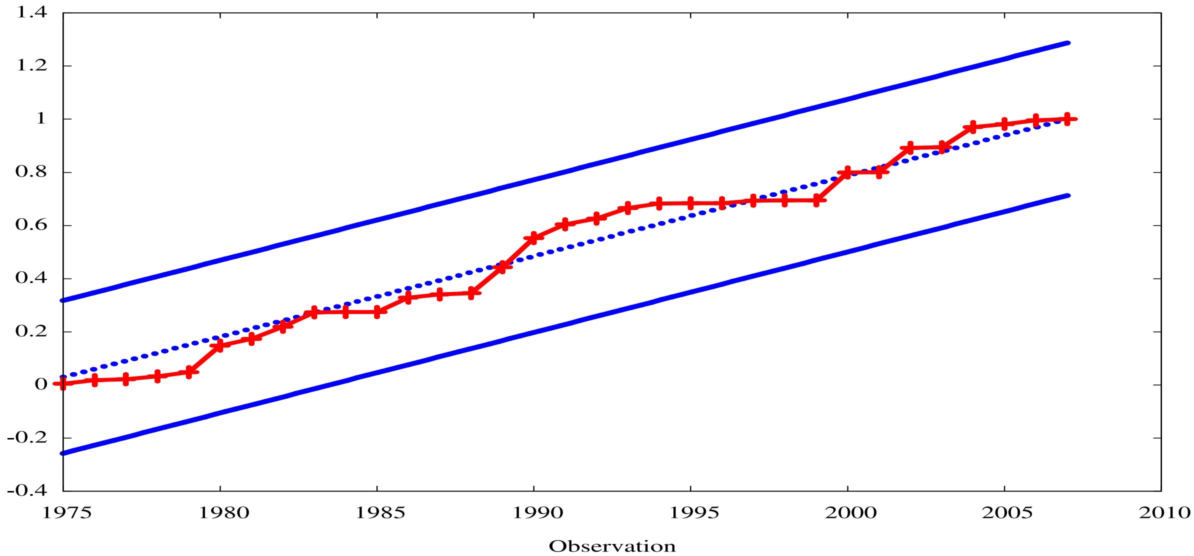


Table A1 : Summary Statistics of the Variables

	C	y	y2	y3	T	M	A	S
Mean	0.581865	1523.765	2428846.	4.07E+09	55.95350	9272.022	71739.39	25339.41
Median	0.647641	1457.091	2123114.	3.09E+09	54.11982	12032.40	59450.70	19324.80
Maximum	1.043542	2526.928	6385366.	1.61E+10	100.0151	27905.00	283913.1	113260.8
Minimum	0.080364	1083.613	1174217.	1.27E+09	30.24358	114.0000	1338.000	323.4000
Std. Dev.	0.282963	330.4766	1153715.	3.19E+09	14.20025	8092.955	79507.05	29476.04
Skewness	-0.289337	1.265957	1.827261	2.403793	0.708718	0.254942	1.138277	1.407542
Kurtosis	1.858835	4.516962	6.592484	9.214841	4.175840	1.958992	3.465490	4.250948
Jarque-Bera	3.342459	17.78652	53.61717	126.0467	6.924767	2.743345	11.02372	19.37453
Probability	0.188016	0.000137	0.000000	0.000000	0.031355	0.253682	0.004039	0.000062
Sum	28.51137	74664.48	1.19E+08	1.99E+11	2741.722	454329.1	3515230.	1241631.
Sum Sq. Dev.	3.843266	5242308.	6.39E+13	4.89E+20	9679.060	3.14E+09	3.03E+11	4.17E+10
Observations	49	49	49	49	49	49	49	49

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