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Energy, Emissions and the Economy: Empirical Analysis from Pakistan

MUHAMMAD TARIQ MAHMOOD and SADAF SHAHAB

1. INTRODUCTION

It is now an established fact that the most important environmental problem of our era is global warming.[1] The rising quantity of worldwide carbon dioxide (CO2) emissions seems to be escalating this problem. As the emissions generally result from consumption of fossil fuels, decreasing energy spending seems to be the direct way of handling the emissions problem. However, because of the possible negative impacts on economic growth, cutting the energy utilisation is likely to be the "less preferred road". Moreover, if the Environmental Kuznets Curve (EKC) hypothesis applies to the emissions and income link, economic growth by itself may become a solution to the problem of environmental degradation [Rothman and de Bruyn (1998)]. Coondoo and Dinda (2002), however, argue that both developing and developed economies must sacrifice economic growth. Still, countries may opt for different policies to fight global environmental problems, mainly depending on the type of relationship between CO2 emissions, income, and energy consumption over the long run [Soytas and Sari (2006)]. Hence, the emissions-energy-income nexus needs to be studied carefully and in detail for every economy, but more so for the developing countries. In this paper, we investigate the relationship between energy consumption, CO2 emissions and the economy in Pakistan from a long run perspective, in a multivariate framework controlling for gross fixed capital, labour and exports by employing ARDL bounds testing approach.

Pakistan can be a good case study for the analysis because it needs to adjust her infrastructure, economy, and government policies (including environmental, energy, and growth policies) to make them in line with the global requirements of this era. Secondly, amid industrialisation, there has been increasing trend in CO2 emissions in Pakistan since 1990s.

The organisation of the study is as follows: after this brief introduction of the study, in Section 2 we present some background literature relating to theoretical and empirical model; in Section 3 we design the model and methodology; Section 4 discusses some facts about energy sector in Pakistan; Section 5 comprises the empirical findings and the discussion of the results, Section 6 presents the implications of the model for Pakistan economy and conclusions.

Muhammad Tariq Mahmood <tm76pk@gmail.com> is Assistant Professor, School of Economic Sciences, Federal Urdu University of Arts Science and Technology. Sadaf Shahab is Assistant Professor, School of Economic Sciences, Federal Urdu University of Arts Science and Technology.

[1]Report by Intergovernmental Panel on Climate Change [IPCC (2007)].

2. THE THEORY AND THE MODEL

2.1. Background Literature

There are quite a few theoretical studies that formally model a direct link between the environment and growth, energy and growth, and energy and environment. The empirical literature appears to be richer. Initially we underpin some of the theoretical concerns. Then, we introduce the empirical surveys that relate to the transmission mechanisms within the energy-environment-economy (E-E-E) nexus. The theoretical work on economic growth mostly relies on the Solow growth model. More recently growth models depend heavily on the endogenous growth theory. There are a significant number of studies that model the relationship between the natural resource management, environment and economic growth [for review see Xepapadeas (2005)]. Whereas Jorgenson and Wilcoxen (1993) selectively cover the theoretical work that models intertemporal general equilibrium framework to develop the interrelationships between energy, the environment, and economic growth. As claimed by Xepapadeas (2005) early works on the growth failed to take into account of the environmental issues of growth. Reviewing the recent literature, he argues that, "there is a necessity for growth theory to delve deeply into the analysis of the interrelationships between environmental pollution, capital accumulations and the growth of variables which are of central importance in growth theory." p. 1221).

Kolstad and Krautkraemer (1993) point out that the resource use (particularly energy) cede instant economic benefits, its negative blow on the environment may be observed in the long run. Since, most of the theoretical work is dynamic; the empirical studies are mostly static in nature, entailing the need for dynamic empirical analysis. Jorgenson and Wilcoxen (1993) find out that the common feature of the models is relying on the effect of policies on capital accumulation in modelling the relationships between the economy, energy and environment. Theoretically, there may be several transmission mechanisms through which environmental policy and economic growth may relate; partly due to some models considering pollution as an input to production; and partly, as a negative by-product [Ricci (2007)]. Generally, environmental policies are considered to have negative impact on growth, due to their role as additional constraints in the models. Certainly, Dudek, *et al.* (2003) show that the additional benefits from reduction of emissions will exceed the average cost. Hence, the methodology for empirical analysis should base on the dynamic effects in the energy-environment-economy nexus. Theoretical studies mainly believe that any effective policy should take the dynamic nature of the relationships and long run perspective.

The mismatch between theoretical work and empirical studies about the relationship between growth, energy and environment is pointed out by Brock and Taylor (2005) who argue that the key is the so-called Environment-Kuznets-Curve (EKC) literature. Brock and Taylor (2005) find a tighter connection between theory and data. The focus of many empirical studies has been on the relationship between the environment and economic growth [see Dinda (2004); Stern (2004) to review]. The EKC studies that analyse linear [Shafik and Bandyopadhyay (1992); de Bruyn, *et al.* (1998)], plus quadratic and cubic [Canas, *et al.* (2003); de Bruyn, *et al.* (1998); Heil and Selden (1999); Roberts and Grimes (1997)] connection between GDP per capita and CO2 emissions, could not confirm agreed-upon findings. Dinda (2004) find a dynamic link between CO2 emissions and income and CO2 emissions may lead to economic growth. It may still be possible to observe the emissions to lead to energy use if the energy production process of a county is responsible for a major portion of emissions.

In another line of empirical research, there are a sizeable number of studies that examine the bond between energy use and economic growth. Since Kraft and Kraft (1978), the literature has tested the Granger (non) causality between energy and income with miscellaneous results [Akarca and Long (1980); Yu and Hwang (1984); Erol and Yu (1987); Hwang and Gum (1992); Glasure and Lee (1997)]. Most of these studies faced a numerous methodological setbacks; particularly the omitted variables bias. In this regard the first significant study is Stern (1993) who supports using a multivariate analysis. Following Stern (1993), many studies employed recent and powerful time series techniques, [see for example, Stern (2000); Asafu-Adjaye (2000); Yang (2000); Sari and Soytas (2004); Ghali and El-Sakka (2004); Lee (2006)]. Nevertheless, this line of research also failed to accomplish common objectives. For instance, Soytas, *et al.* (2007) study the long run Granger causality between emissions, energy use, and growth for US economy, with additional variables such as labour and capital. Though they do not find any evidence of causality between carbon emissions and income; and energy consumption and income, but verify that energy use is the foremost source of emissions.

In both directions of literature, and particularly in the EKC literature, the large size of the work is on developed economies. There is still very limited literature that studies the link between energy use, economic development and environmental degradation in Pakistan, yet alone the dynamic link between CO2 emissions and income. Siddiqui (2004) in this regards is one of the pioneer studies that analyses the link between energy and economic growth. According to the results of her model, energy is a major source of economic growth and indicates the possibility of inter-fuel substitution, which may be a result of changes in price structure, Recently, for Pakistan economy some other studies are done, e.g., Nasir and Rehman (2011), who find mixed results and do not support the idea of EKC in the short run. Shahbaz, *et al.* (2010) study suffers from the theoretical issues of endogeneity and multicollinearity.

2.2. Model

In this paper we investigate the dynamic relationship between energy use, CO2 emissions and GDP [as suggested by Xepapadeas (2005); Kolstand and Krautkraemer (1993); and Jorgenson and Wilcoxen (1993)] in an emerging Asian economy, accounting for possible effects of labour and fixed capital formation.[2] The paper attempts to make a contribution to the existing empirical literature by combining the two lines of empirical research in a developing, economy using relatively new time series techniques that cater to some of the methodological issues of the past studies. Besides, the choice of the variables is not random or arbitrary but relies on theory,[3] which may be missing from many empirical studies. We hope the empirical results of this study may be helpful in guiding policy makers to devise long run sustainable policies.

[2]To account for capital accumulation as suggested by Jorgenson and Wilcoxen (1993).
[3]As proposed by Brock and Taylor (2005).

$$Y = f(E, CO2, K, L, X) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where Y is log of real GDP in Rs Million,

E is log of energy consumption, converted to Giga-watt-hours.
$CO2$ is the log of emission of carbon dioxide per capita measured in tons,
K is the log of gross fixed capital formation, in Rs. Million,
L is log of employed labour force in Million persons and
X is the log of exports in Rs Millions.
The econometric specification of the model will be;

$$Y = \alpha_0 + \alpha_1 E + \alpha_2 CO2 + \alpha_3 K + \alpha_4 L + \alpha_5 X \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Where expected signs of the parameters are: $\alpha_1 > 0, \alpha_2 < 0, \alpha_3 > 0, \alpha_4 > 0, \alpha_5 > 0.$

3. METHODOLOGY AND DATA

3.1. Methodology

For this model we develop a methodology based on the Pesaran, *et al.* (2001), that provides a bounds test approach to find out the short and long run relationships among the variables of interest. It would also be based on the results of the unit root test. *A priori*, we can assume different order of integration of the variables of the model. This is made clear in Section 5.1.

The Pesaran, *et al.* (2001) methodology is based on the Autoregressive Distributed lag model. The ARDL approach involves two steps for estimating the long-run relationship. The first step is to examine the existence of a long-run relationship among all variables in the equation under examination. Conditional upon the confirmation of cointegration, in the second stage, the long-run coefficients and the short-run coefficients are estimated using the associated ARDL and ECMs. To test for cointegration in model (2) by the bounds test, the following conditional Unrestricted Error Correction Model (UECM), is constructed

$$\begin{aligned}\Delta y_t &= \alpha_0 + \Sigma\, \alpha_i \Delta y_{t-i} + \Sigma\, \alpha_j\, \Delta E_{t-j} + \Sigma\, \alpha_k \Delta CO2_{t-k} + \Sigma\, \alpha_m \Delta K_{t-m} + \Sigma\, \alpha_n \Delta L_{t-n} \\ &\quad + \Sigma\, \alpha_s \Delta X_{t-s} + \theta_0\, y_{t-1} + \theta_1 E_{t-1} + \theta_2 Co2_{t-1} + \theta_3 K_{t-1} + \theta_4 L_{t-1} + \theta_5 X_{t-1} + e_t \quad \ldots \quad (3)\end{aligned}$$

Notice that this is almost akin to traditional Error-Correction Model. The alphabets i,j,k,m,n and s in the subscript of each variables define the lag structure of that variable. If the optimal lag length is found one using Schwarz criterion, then this lag length is used for each variable. To investigate the presence of long-run relationships among the Y, E, $CO2$, K, L and X, under the bounds test approach formulised by Pesaran, *et al.* (2001), after regression of Equation (3), the Wald test is applied. The Wald test can be conducted by imposing restrictions on the estimated long-run coefficients of Y, E, $CO2$, K, L and X, The null hypothesis is H_0: $\theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ where there is no cointegration among the variables. The F-stat is computed and compared with the critical value (upper and lower bound) given by Pesaran, *et al.* (2001). If the F-computed exceeds the upper critical bound, then the hypothesis of no cointegration will be rejected. However, if the F-computed is less than the lower critical bound, then H_0 cannot be rejected, concluding that there is no cointegration among the variables. If the F-computed falls between the lower and upper bounds, then the result is inconclusive.[4]

The empirical evidence for the existence of an EKC has been found in various studies. These studies share some common characteristics with respect to the data and methods employed. Most of the data used in these studies are cross-sectional/panel data. The following reduced form model is used to test the various possible relationships between pollution level/environmental pressure and income:

$$log\ (co2/capita) = \beta_0 + \beta_1\ log(GDP/capita) + \beta_2\ log(GDP/capita)^2 + \beta_3\ log(GDP/capita)^3 + Log\ E + u \quad \ldots \quad (4)$$

Here all the variables are self-explaining. Model (4) provides us to test several shapes of environment-economy development relationships where energy demand is used an intervening variable. It follows;

I. $\beta_1 = \beta_2 = \beta_3 = 0$. A flat pattern or no relationship.
II. $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$. A monotonically increasing relationship or a linear relationship between environment and economy.
III. $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$. i.e., monotonically decreasing relationship between both.
I. $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 = 0$. An inverted-U-shaped EKC.
II. $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 = 0$. A U-shaped curve.
III. $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$. A cubic or N-shaped curve.
IV. $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$. Opposite to N-shaped curve.

3.2. Data

Our empirical findings are based on the data from different sources. We obtained GDP, exports and CO2 emission data from World Bank (WB); Employed Labour Force from Pakistan Economic Survey (PES) and SBP website; Gross Fixed Capital Formation (GFCF) from IFS; and energy from PES and WB. The data are used in log form. The currency unit of the GDP, exports and GFCF is Rupees in Million. Since we are using aggregate data of energy, these are converted into single unit by applying scientific formulae of the measurement of energy. The tons of fuel consumption, the million cubic feet of natural gas, and metric tons coal consumption are used to convert each energy source into Giga-watt Hour (Gwh) of energy it could produce. The electricity consumption is already measured on Gwh. There could be many other units of energy, e.g., joules, calories, etc., but the measureable values of these units would have increased enormously, which would be difficult to use. This calculation method and data can be obtained from the authors upon request. The time period of the study is 1973–2012. It is the post-separation period, however, considering the issue of degrees of freedom for time series analysis we have tried to use 40 years' annual data.

4. PAKISTAN: SOME ENERGY FACTS

Table 1 shows the energy highlights of supplies in Pakistan energy sector, which include both imported and exported sources of the supplies. The issue of utilisation of resources remains typical. The demand of energy resources mainly originates from: households, industry, agriculture, transport power and government.

[4]This perhaps reminds of the *old DW* test for serial correlation.

Table 1

Highlights of Energy Sector in Pakistan

Highlights	Units	Energy Supplies 2011-12
Crude Oil Production	000 barrels	24,573
Production of Gas	Mcf	1,558,959
Production of Coal	000 tonnes	3,472
Import of Coal	000 tonnes	3,850
Electricity	MW	
Hydel	MW	6,557
Thermal	MW	15,392
Nuclear		787
Total Capacity		22,736

This table is copied from Statistical Bulletin of Pakistan Economic Survey, 2013.

Over the years the demand of energy has increased manifold, particularly for transportation and industrial sectors. Figures, A1–A5 in the appendix present analysis of demand sources for energy. The consumption share of natural gas for house hold and industrial use increased during last twenty years, while the share of power sector decreased during this period. The cement sector has substituted the energy use from gas to coal. The fertiliser sector has also shown a decrease in its percentage share of the use of gas. Transportation has increased its share in use of natural gas, but during last two years, it shows a downward trend in its growth. Transportation and power sectors are the major consumers of the oil products throughout the period of analysis, and their share has increased over time. The household, agricultural and industrial consumption of oil products has decreased during last twenty years. Households are the largest consumer of electricity. The share of industrial sector decreased about 10 percent over the last two decades. This reflects that the resource substitution by the industrial sector from relatively costly (electricity) to cheaper (gas) one. Coal being the least technically applied source has never been preferred by the industrial sector before 1990s. The major user (about 90 percent) has been brick kilns. The cement sector started using coal in 2001 and now its share of total use has increased to 61 percent, which reflects resource substitution. Households and power sector reduce use of coal. Power sector peaked its use of coal in late 1990s. Figure A5 shows the growth rate of the energy demand. The demand for coal has shown huge oscillations whereas gas consumption has been steady. The use of coal and electricity have shown similar trends, while the use of gas and oil products has shown the same pattern. The consumption of electricity has also been volatile during past forty years.

5. EMPIRICAL FINDINGS

5.1. Unit Root Test

Table 2 presents the results of the unit root test using ADF test. The series of CO2 emissions, GDP growth rate, exports and population are significant at level, i.e., they do not exhibit stochastic trend. Both GDP and GDP growth have significant intercept, despite different orders of integration. The result of exports (ex) has shown interesting feature: Pakistan's export are stationary at level; but with significant trend and intercept. This is deterministic trend, not the stochastic one. The distinction between a deterministic and stochastic trend has important implications for the long-term behaviour of a process: (i) time series data with deterministic trend always revert to the trend in the long run (the effects of shocks are eventually eliminated) the intervals for forecasting comprise constant width; (ii) time series with a stochastic trend never recover from shocks to the system (the effects of shocks are permanent). Forecast intervals grow over time. Thus the stochastic trend in GDP, energy demand, energy supply and imports show that these series are difference stationary.

The maximum order in integration is one in this model while minimum is 0, so we cannot apply general cointegration technique [e.g., Johansen and Juselius (1990)] on this model. We confirmed that none of the variables in the model is I(2) using KPSS test. So the mixture of order of integration confirms the use of autoregressive distributed lags (ARDL) model and long run causality test. We apply ARDL model.

Table 2

Test of the Stationarity of the Variables

Variable	Parameter	ADF cal	5%	Lag	Trend/ Intercept	Inference
CO2	–0.053303	–4.54	–1.95	1	None	Level
GDP	–0.673	–4.30	–2.93	0	Intercept	1st Dif
Energy	–0.49	–3.42	–1.95	0	None	1st Dif
Growth	–0.700	–4.52	–2.93	0	Intercept	Level
Exports	–0.56	–3.59	–3.53	1	Both	Level
Labour	–0.452	–4.01	–3.53	0	Both	Level
Capital	–0.36	–4.21	–3.53	0	Both	Level

On the basis of SC we have selected one lag for this model. So this lag length will be used to estimate the unrestricted ECM for the bounds test.

5.2. The Long run

The long run analysis of our E-E-E model[5] is based on the UECM used in econometric literature. The evidence of such modeling procedure is Narayan (2004), Altinay (2007) and Sultan (2010). Most of the individual coefficients are statistically significant at 5 and 10 percent level of significance. Here our objective is to compute F stat using Wald test of joint significance of this unrestricted model to test the hypothesis of long run relationships among the variables. To compute F–state for bounds testing, we applied Wald test of joint significance of coefficients θ_0, θ_1, θ_2, θ_3, θ_4 and θ_5. Table 3 presents the estimates of *Autoregressive Distributed Lag Model* of Equation 3.

[5] Energy-Environment-Economy Model.

Table 3

Unrestricted Error Correction Model for Pakistan Economy

Variable	Coefficients	Standard Error
Constant	–2.2463	1.286**
Δy_{t-1}	–0.042	0.019*
ΔL_{t-1}	–0.112	0.07***
ΔK_{t-1}	–0.048	0.027**
ΔX_{t-1}	–0.0127	0.009
ΔE_{t-1}	–0.0369	0.024
$\Delta CO2_{t-1}$	0.0188	0.13
y_{t-1}	–0.197	0.121**
E_{t-1}	0.3361	0.107*
$CO2_{t-1}$	–0.237	0.131**
K_{t-1}	0.0689	0.026*
L_{t-1}	0.088	0.066
X_{t-1}	0.0263	0.021
R–sq	0.622	

*,** means individual coefficients are significant at 5, and 10 percent.

Diagnostic Tests

In dynamic time series analysis the selection of variables for a model is critical. Almost all individual time series, which show trend, are supposed to have serial correlation and specification problem. But to use a time series model we have to perform some diagnostic tests on the model of unconstrained/unrestricted error correction model. Table 4 shows that our specified UECM passes all the diagnostic tests, i.e., (i) The residuals are normally distributed, because we fail to reject the null of Normality in JB test; (ii) the F-stat in Ramsey RESET test shows that model is correctly specified; (iii) For serially independent residuals, we used BG LM test and failed to reject the null hypothesis of no auto correlation.; and (iv) and the variance of residuals is persistent, as pointed by ARCH LM test for the estimated model.

Table 4

Diagnostic Tests

Diagnosis	Test	Stats
Normality Test	Jarque Bera	JB Stat: 2.31 (0.31)
Specification Test	Ramsey RESET	F-Stat: 0.232 (0.635)
Serial Correlation Test	B-G LM Test	Chi-sq: 2.74 (0.11)
Hetroskedasticity	ARCH LM	F: 0.095(0.76), Chi-sq: 0.099 (0.75)

For the dynamic stability of the UECM model, the inverse roots before and after differencing (Figure A6 and A7 in the Appendix) are confirmed. The before differencing inverse root exhibits the instability, thus differencing is required. After differencing none of the roots lay on the X-axis, it's clear that we have three complex pairs of roots. Accordingly, the short-run dynamics associated with the model are quite complicated.

For the bounds test, the F-stat 4.48 is compared with lower bound at 5 percent level of significance from the Pesaran, *et al.* (2001) in case III in the Table the relationships are tested at level, which show drift but no intercept at $k = 5$.

Table 5

Cointegration Properties

Dependent Variable	F-Statistics	Critical Bound Bottom I(0)	Top I(1)
Δy_t	4.48	2.62	3.79

The statistics in Table 5, shows that the computed F-stat is greater than the upper bound, indicating the existence of long run relationships between variables of the model. Thus cointegration exists and the estimated coefficient of Equation 3 can be used to calculate the long run elasticities of the model. The long run elasticities can be computed as:

$$\xi_{y,E} = -(\theta_1/\theta_0) = 1.70$$
$$\xi_{y,co2} = -(\theta_2/\theta_0) = -1.20$$
$$\xi_{y,K} = -(\theta_3/\theta_0) = 0.35$$
$$\xi_{y,L} = -(\theta_4/\theta_0) = 0.447$$
$$\xi_{y,X} = -(\theta_5/\theta_0) = 0.133$$

In the long run one percentage increase in energy use leads to 1.7 percent increase in GDP. The energy is positively linked with aggregate demand. On the contrary, the effect of carbon emissions on economy is negative. These absolute values of the two elasticities are greater than unity. Thus reflecting, the negative externality produced from the use of energy (particularly use of fossil resources) in the shape of CO2 emission can retard economic growth. Nevertheless, the net effect of energy is positive (i.e., 1.70–1.20 = 0.5) and less than unity. This implies that for Pakistan still we can use the energy resources with positive output effect.

Similarly the positive elasticities of capital and labour reflect that both have standard theoretical interpretation, but interestingly, in the presence of externalities, these results imply decreasing return to scale production function. The exports elasticity of demand is very low and statistically insignificant. This result contradicts theory, yet, due to the presence of the factors that directly affect the economy, the effect of exports on GDP remained insignificant.

5.3. The Short Run

For short run we estimated the error correction model of Equation 3, by estimating the logged model at levels then used error term as an explanatory variable in the error correction model. The Results are presented in Table 6. We can notice that the coefficient of error term Z_t is negative and statistically significant, which also confirms the existence of cointegration between the variables of the model. The magnitude of the coefficient implies that about 16 percent of the disequilibrium is corrected in one period of time.

Table 6

Short Run Properties

Variable	Coefficients	Standard Error
Constant	0.03596	0.0108*
Δy_{t-1}	0.398859	0.203*
ΔL_{t-1}	–0.04671	0.066
ΔK_{t-1}	–0.05193	0.03**
ΔX_{t-1}	–0.00461	0.03
ΔE_{t-1}	0.117681	0.0630**
$\Delta CO2_{t-1}$	–0.17135	0.104**
Z_t	–0.161	0.090**

*,** Means individual coefficients are significant at 5, and 10 percent respectively.

5.4. Environmental Kuznets Curve

Our model so far has shown important implications for the Pakistan economy. This E-E-E model is now being used under the methodology discussed in the end of section 3.1, where we developed seven hypotheses to be tested for Equation 4. The estimated version of this equation is given below;

$$\log(\text{co2/capita}) = -2.165 - 1.58 \log(\text{GDP/capita}) + 0.18 \log(\text{GDP/capita})^2 - 0.0067 \log(\text{GDP/capita})^3 + 0.517 \text{ Log } E + u$$

(*Note:* all the coefficients are statistically significant at 1 percent level of significance.)

According to our setting in section 3.1, we find that hypothesis (iv) which reflects EKC does not hold in case of Pakistan's data. Rather it is a cubic and opposite to an *N*-shaped curve as assumed in hypotheses (iv). Hypotheses (i) is rejected through Wald test.[6] In nutshell, we can declare that the EKC is not in place in Pakistan, given the energy use data. This cubic function also elaborates that at the early stages of economic growth, Pakistan has been an agrarian economy, with less use of fossil fuels and had not any environmentally negative impact. But with the wave of industrialisation, over the long run the emissions grow and after some point in time when a certain level of GDP per capita is achieved, the environmental degradation increases. Thus this curve, which is monotonically decreasing at early stages of growth, starts increasing at higher income levels; and after some turning point, it will look like an EKC. Since, EKC have been used as an argument that economic growth and increased environmental quality go hand in hand, this may not be true for the case of developing countries [Richmond and Kaufman (2006)].

6. CONCLUSIONS AND POLICY IMPLICATION

In this study we have used an ARDL approach to find the long run nexus between E-E-E and found some robust results after estimating the long run elasticities. The demand elasticity of energy is positive and greater than unity, but the negative externality produced due to the use of energy, may reduce this effect. The elasticities of capital and Labour show that due to negative by-products of energy use, the production function

[6] To conserve space and time, we do not present these Wald test results here.

exhibits decreasing returns to scale (this hypothesis needs further investigation). We also estimated the model to test the EKC in the presence of energy demand and find no such evidence. The energy substitution behaviour is found as claimed by Siddiqui (2004), particularly industrial/ cement sector has switched from the use of other resources to the coal. In summary we can derive the following implications of our analysis.

Implications

It is found that the energy use has positive impact on economy. There is an urgent need to explore more sources of energy which can be helpful in meeting the increasing demand of energy.

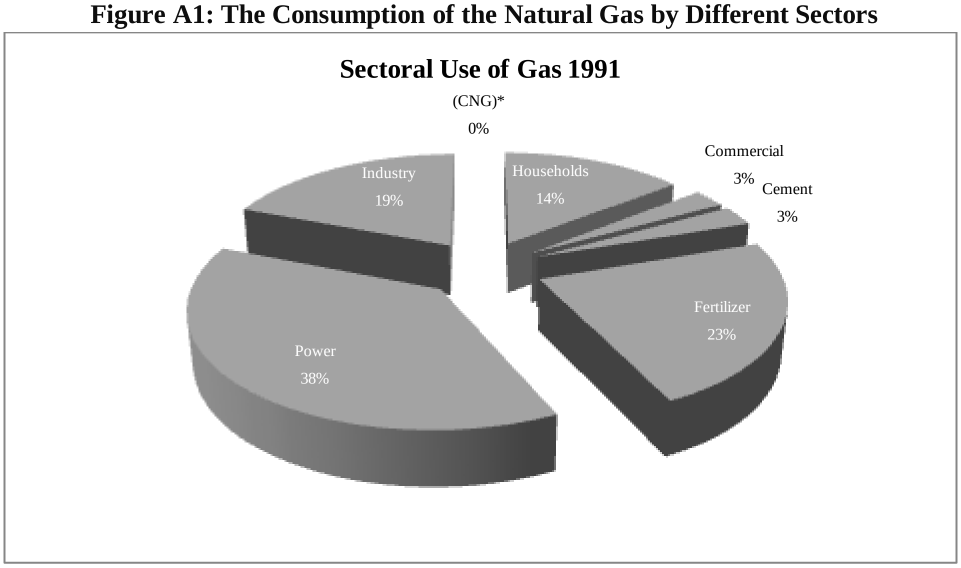
The fuel substitution from costly to cheaper one should be monitored by the government and carbon tax should be imposed on the industries that produce more pollutants. The green technologies can reduce these pollutants.

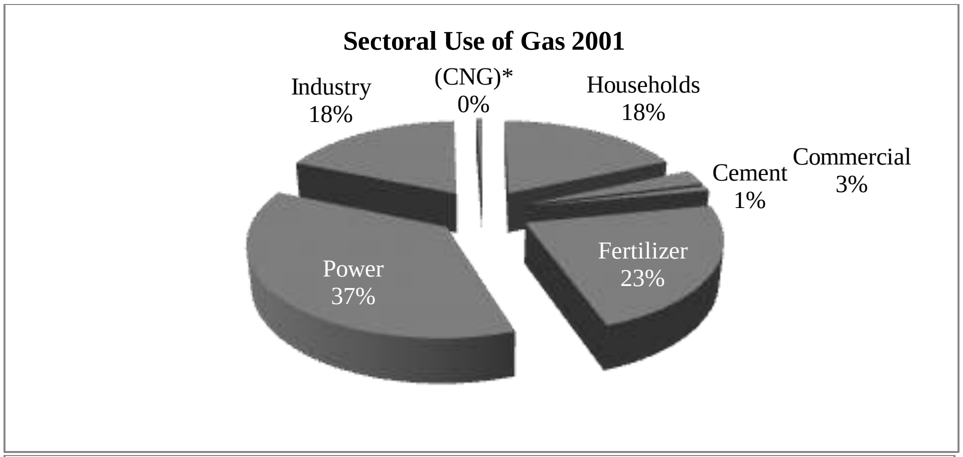
The EKC is used to support *do nothing* policy, which unfortunately cannot happen for the case of Pakistan. This also may not be useful due to turning points that make us to think of the factors that explain it, before making assessments about the necessary components of environmental policy. After an initial stage of economic development we have to take serious measures to tackle the issues of environmental degradation (as a result of energy use). The scale effect suggests that in the beginning of industrialisation and urbanisation, Pakistan should improve the factors' productivity. However, considering energy a separate factor of production, energy efficiency may also increase the efficiency of labour and capital.

This analysis is limited in many ways. For future research the EKC can be tested for the turning points. This would be interesting to find out (numerically) the income per capita that limits the relationship between E-E-E.

APPENDIX

Figure A1: The Consumption of the Natural Gas by Different Sectors





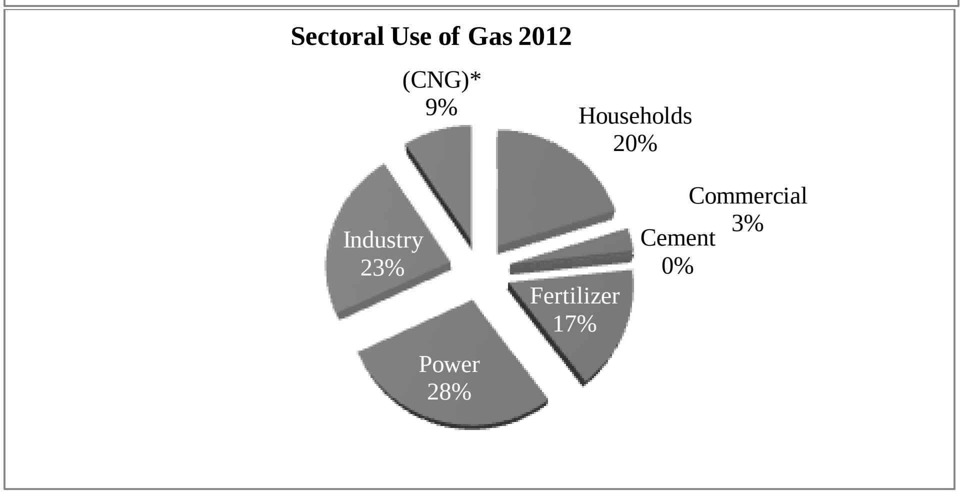
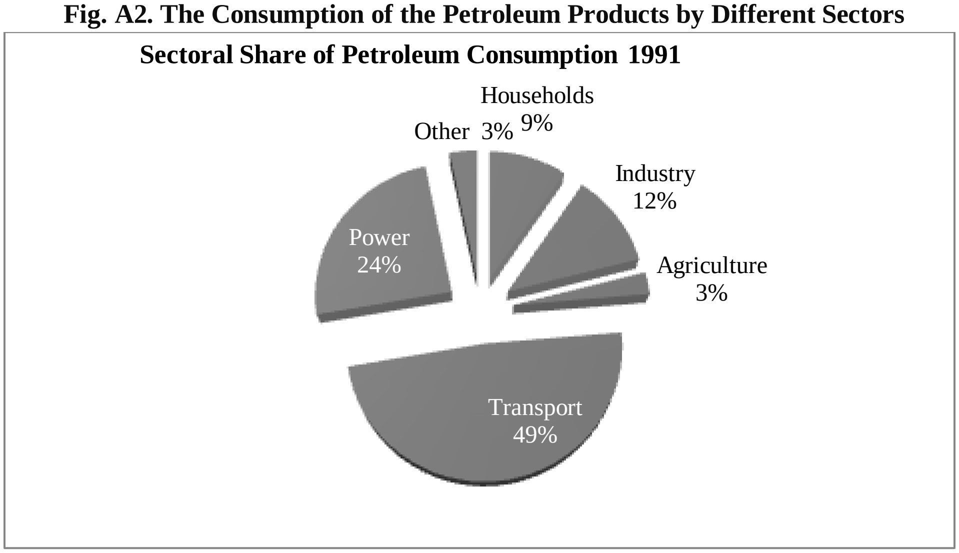
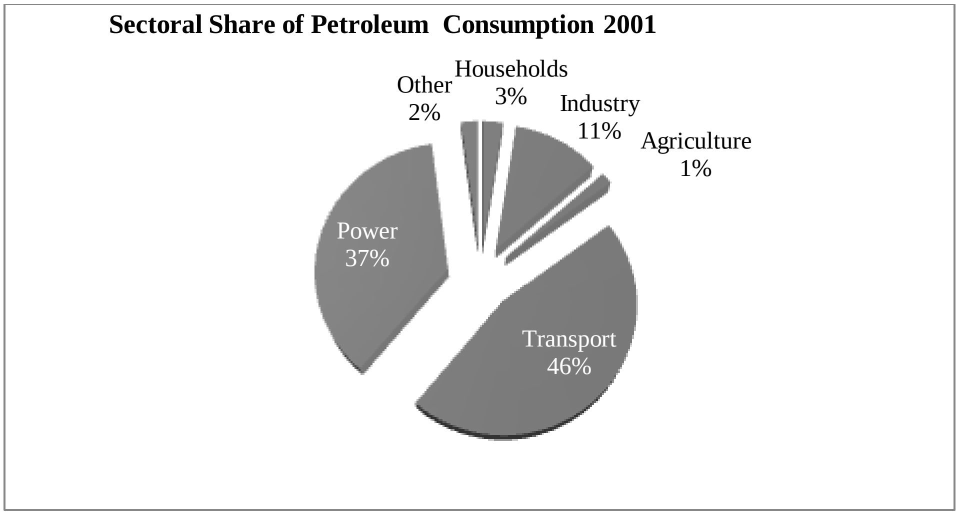


Fig. A2. The Consumption of the Petroleum Products by Different Sectors





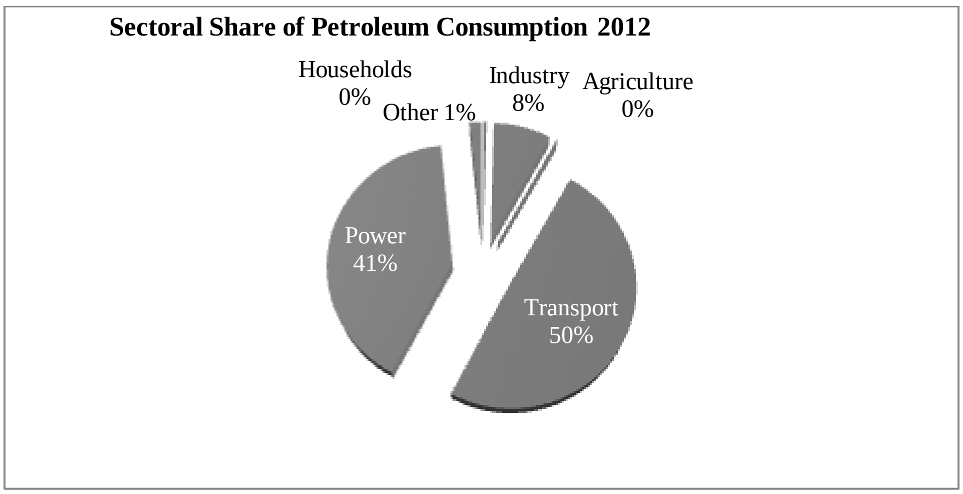
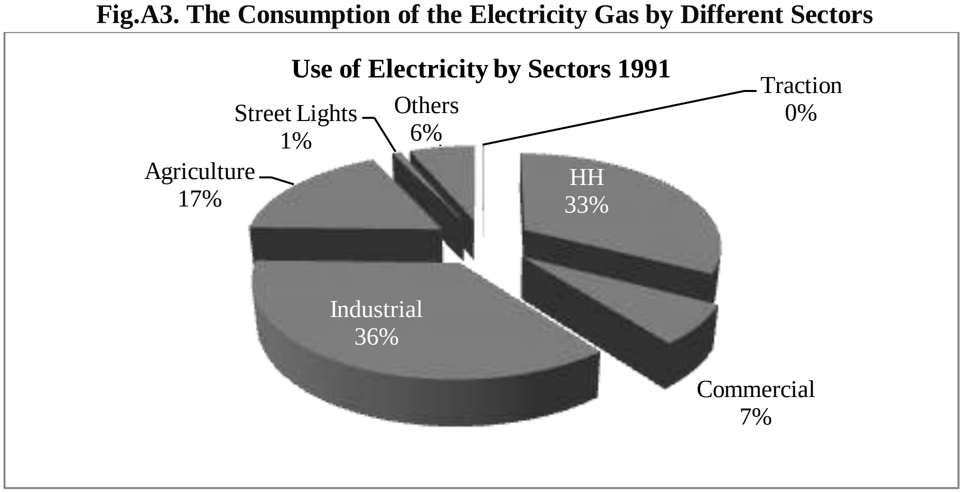
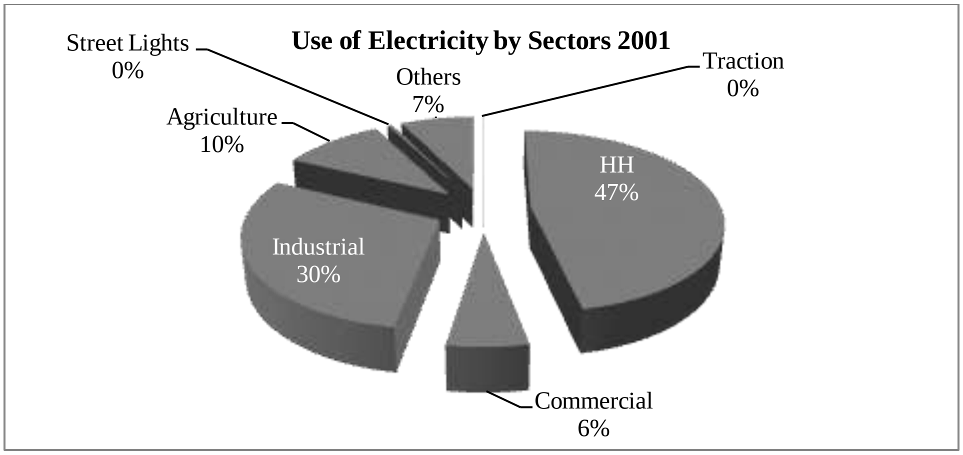


Fig.A3. The Consumption of the Electricity Gas by Different Sectors





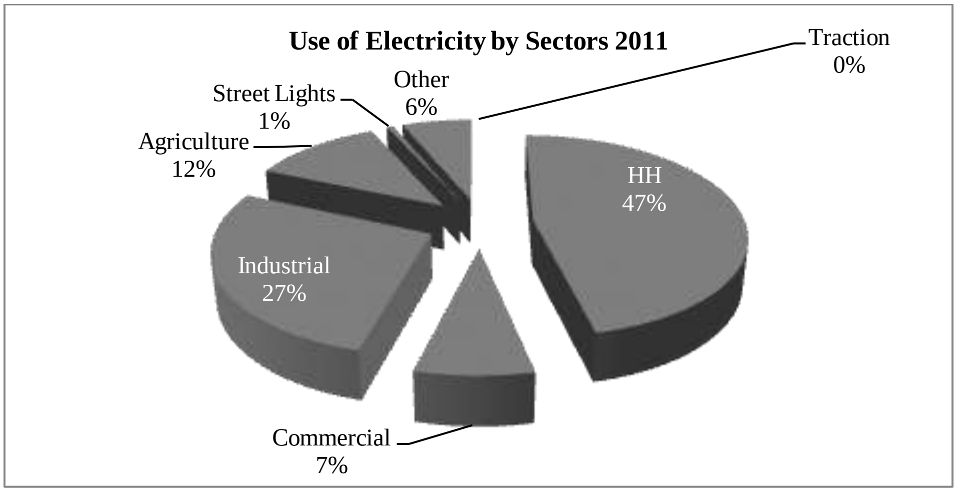
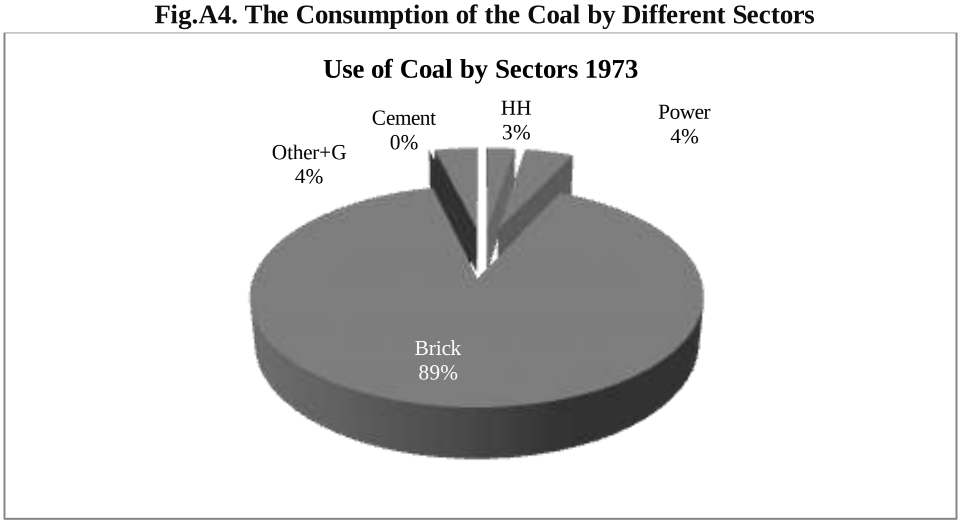
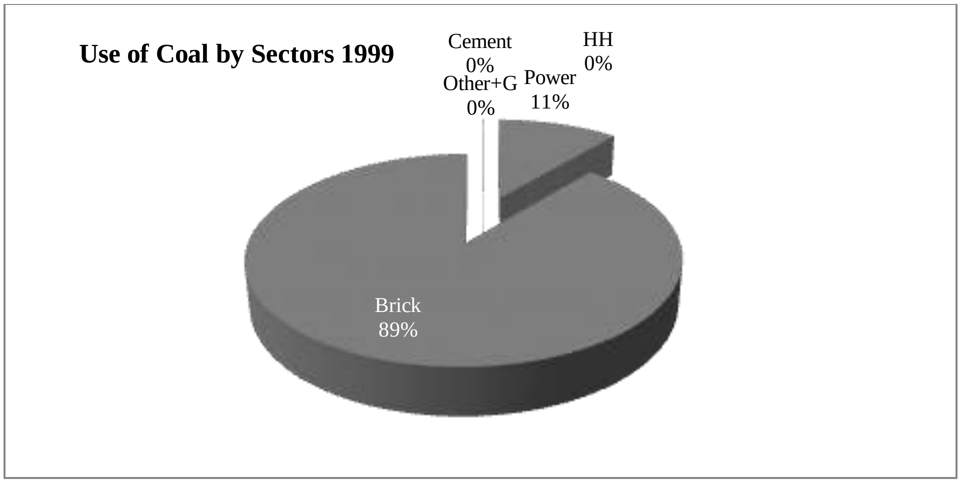
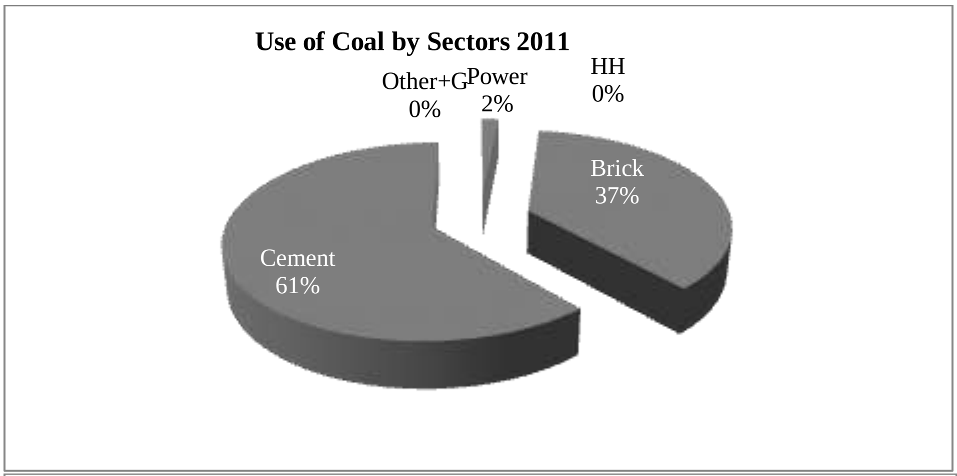


Fig.A4. The Consumption of the Coal by Different Sectors







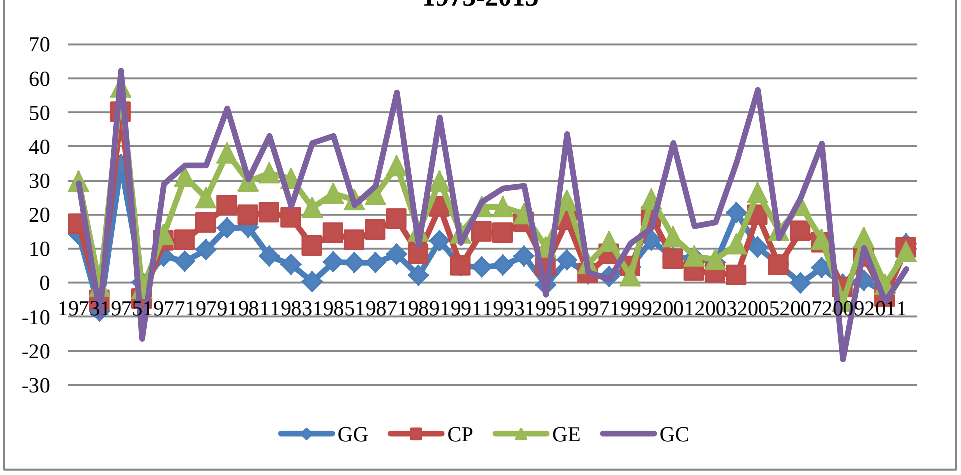


Figure A5: Growth Rate of Energy Consumption of Sources 1973-2013

Figure A6

Inverse Roots of AR Characteristic Polynomial

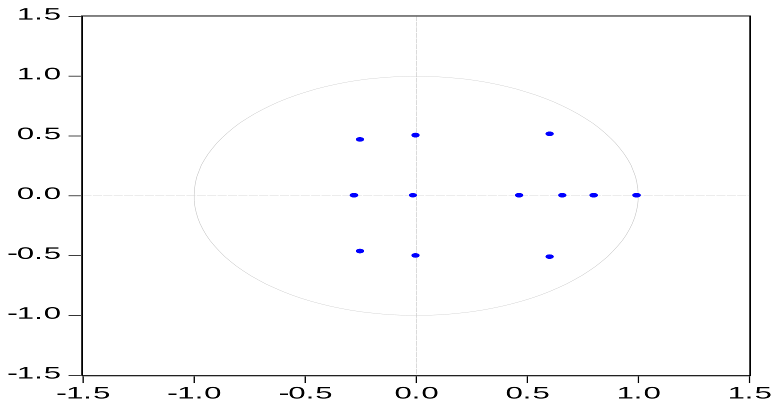
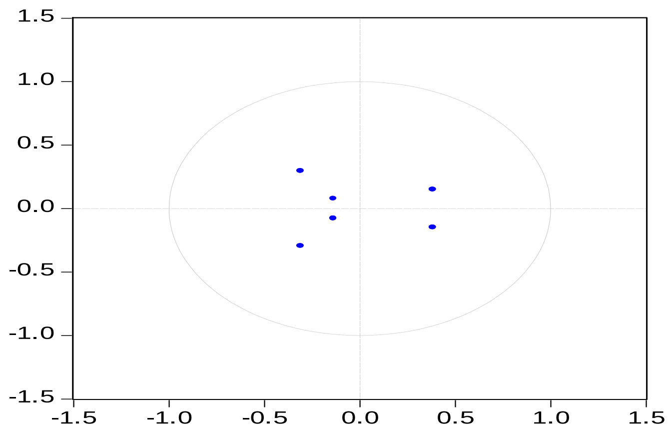


Figure A7

Inverse Roots of AR Characteristic Polynomial



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Comments

The authors have done a good analysis of the issue. However, I have the following minor comments.

(1) Very old review of literature- no reference is available after the 2007. This may be the reason behind the claim that this phenomenon has not been tested so for. I wonder why the writer did not quote more recent studies on the same topic in case of Pakistan. For example Shahbaz, *et al.* (2010), Nasir and Rehman (2011) and Ahmad (2012) have analysed the EKC for Pakistan. The three studies find the existence of the phenomenon in Pakistan. The author could not explain that how their study is different from these studies. These studies have also used ARDL approach.

(2) The author has not explained what the methodological issues of the past studies faced that the ARDL will cater for. Moreover the author is not sure about the variables selection that was missed in the previous studies.

(3) The ARDL is the standard methodology and the author has given unnecessary detail of the methodology that can be avoided. For example if Fc is greater than tabulated than rejected or accepted. This does not make sense.

(4) I could not find the data span in the paper as author has not given any detail that for how many years' data has been used.

(5) Implications or suggestion are insufficient and ordinary, they should be specific to the study objective.

Muhammad Iftikhar-ul-Husnain

COMSATS Institute of Technology,
Islamabad.