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17. September 2011

Online at <http://mpra.ub.uni-muenchen.de/33469/>  
MPRA Paper No. 33469, posted 17. September 2011 / 00:00

# **Industrial Development, Agricultural Growth, Urbanization and Environmental Kuznets Curve in Pakistan**

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## **ABSTRACT**

The debate of environmental issues and their analysis is of vital interest for economic policies. Institutions are engaged in identifying and estimating the extent of environmental impact of determinants controllable via policy measures. Annual data from the on Carbon Dioxide emission, economic growth, consumption of energy, openness for foreign trade, urbanization, industrial growth and agriculture growth on Pakistan is used for 1971 to 2007. Augmented Vector Autoregression technique and cointegration analysis is implemented to test Granger causality. Gross domestic product significantly Granger causes emission of Carbon Dioxide and energy consumption. On the other hand emissions of CO<sub>2</sub> affect economic growth, agriculture and industrial growth in the long run. It is also evident that energy consumption unidirectional Granger causes emission of Carbon Dioxide. Industrialization and urbanization bidirectional Granger causes each other. The results indicate the more careful industrial and energy policies to reduce emissions and control global warming.

**Keywords:** Pakistan, Carbon Dioxide emission, Environment, Energy Consumption, Economic Growth, Foreign Trade.

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## 1. Introduction

Combined global land and ocean surface temperature for January 2010 on the average was 0.60°C (1.08°F) above the 20<sup>th</sup> century average of 12.0°C (53.6°F) and the average global temperature for January 2010 at the surface air was recorded 0.83°C (1.49°F) above the 20<sup>th</sup> century average of 2.8°C (37.0°F). Global warming is partly; result of higher night temperature and partly due to rapid urbanization. Other factors adding towards global warming are the continuously changing irrigation systems, desertification and variations in the use of local lands. Global warming has been an issue of great debate in the last and current century. Several international organizations and local institution are constantly perusing efforts to reduce the level of global warming and to safeguard humanity from the hazardous effects of increasing global temperature during the last few decades (NOAA, (2010) and Karl et al., (1993).

Global warming is related to the increased atmospheric concentrations of Greenhouse Gases (GHG) (Watson et al., 1995). Global warming, major desertification and deforestation and its consequential impact on health, are the main reasons of the emergence of Kyoto Protocol. GHG include naturally occurring water vapour, carbon dioxide, methane, and nitrous oxide and some human-made gases used for aerosols. After its promulgation in 1997, Kyoto Protocol has as of 2010, 84 Signatories and 193 Parties including Pakistan. Objective of Kyoto Protocol is to reduce emissions of GHG and other contaminated gases under the United Nation's Framework Convention on Climate Change. It promotes and develops guidelines to coordinate efforts to reduce the alarming levels of global warming and to overcome the related issues. Furthermore the protocol requires the 37 highly industrialized countries including the European community to reduce their total emissions by 0.5% as of 1990 levels. Pakistan has also signed the climate change convention in 1992 and has ratified the Protocol in 2005(GOP, 2003).

Pakistan has been among the most populous countries in the world ranked at the sixth position. It relies on the imports of capital goods and energy resources to promote industrial growth and economic development. The imports of capital goods and energy resources jointly contribute above 70% towards its total imports while the consumption share of manufacturing and transportation ranges between 30-35% (FBS, 2010). On the other hand, major exports from Pakistan include agricultural products. Agriculture is considered a lower CO<sub>2</sub> emitting sector compared to industrial production. Furthermore, Pakistan is a net importer of fertilizer and other chemical products considered highly emitting contaminated

gases. Hence, it is assumed that foreign trade does not contribute significantly towards CO<sub>2</sub> emissions in Pakistan. The hypothesis is tested using the impact of foreign trade, urbanization and mechanization on the causal linkages of CO<sub>2</sub> emission, economic growth and energy consumption. Halicioglu (2009) discussed for the first time, the effects of the foreign trade on the nexus of CO<sub>2</sub> emission, economic growth and energy consumption. Current research adds to the discussion by augmenting the nexus with urbanization and industrialization.

Several papers have analysed the emissions, energy and growth nexus in context of Pakistan utilizing econometric techniques ranging from traditional causality and cointegration analysis to bounds testing approach of Autoregressive distributed lagged models. The model selection is dependent the computational feasibility and available data. This paper investigates the EKC augmenting with the potential impact of urbanization and industrialization (Shahbaz et al., 2009). Urbanization is assumed to motivate emissions as it is the result of high agriculture growth and industrial development. Growth of agriculture due to mechanization has resulted in increased demand for energy resources like electricity which is produced from the hydrocarbon, and oil has been imported to meet the requirements. Imports of oil resources have been documents to contribute heavily towards total international trade of Pakistan (Alam et. al., 2007 and Shahbaz, 2009). The paper deviates from these lines in terms of its using important factors contributing directly or indirectly towards international trade, energy consumption and significant drivers of economic growth in Pakistan. These factors also contribute towards emissions of Carbon Dioxide.

## **2. Literature Review**

The literature on the environment-growth-energy nexus is distinguished into three distinguished streams. First stream focuses on the analysis of relationship between emissions of particles causing pollution and economic growth. It is known as Environmental Kuznets Curve (EKC), a well-known terminology in the economic literature promulgated by Simon Kuznets in 1955, defining an inverted U-shaped relationship between per capita income and the income inequality. According to EKC, an inverted U-shaped relationship has been proposed between environmental pollution and economic growth. Furthermore literature also provides evidence on the existence of a linear, N-shaped or sideways-mirrored S-shaped relationship (Azomahou et al. (2006); Coondoo and Dinda (2008); Galeotti et al. (2006); Managi and Jena (2008); Roca et al. (2001) and York et al. (2003)).

The second stream investigates the relationship between economic growth and energy consumption. The stream explores whether economic growth stimulates consumption of more energy resources or energy consumption enhances economic growth. An aspect of such studies is to study issue related to efficiency in the consumption of energy at higher levels of economic development. Empirical research in the stream evaluates the effects of higher energy use on economic growth. It is led by a seminal paper by Kraft and Kraft (1978), further research in a bi-variate framework by Narayan and Sing (2007); Narayan et al. (2008) and Wolde-Rufael (2009). The studies are considered to face issues of specification bias potentially due to omission of concomitantly important indicators as suggested by Streen (1993).

Finally the third stream focuses on the joint investigation of the three relationships in a multivariate framework. Ang (2007); Soytaş et al. (2007); Gosh, 2010) and Zhang and Cheng (2009) and adding foreign trade into the nexus by Halicioglu (2009). The stream of research investigates the relationships between energy consumption and economic growth, economic growth and environmental degradation and energy consumption and environmental degradation. Foreign trade is assumed to improve the explanatory power of the three causal linkages on the assumption that countries exports low emitting products to and imports high emitting production from developing countries. It is assumed as indirectly exporting the emission to lower income countries specialising in industrial production of high emitting products. The research still lacks anonymity in findings among the list of a significantly positive relationship, negative or even no relationship.

The Environmental Kuznets Curve hypothesizes a positive relationship between environmental pollution and economic growth as indicated by the findings of Shafik and Bandyopadhyay (1992), Azomahou et al, (2006) and many others. Economic history also provides evidence on a positive and a linear relationship between emissions and economic growth during the initial times, where focus of most countries remains on the achievement of higher economic growth compromising on the environment. Later on, and as countries develop, more efforts are emphasized to control contaminated emissions with increasing level of gross domestic product, the relationship tends to be an inverted U-shaped relationship during the economic history of nations (Cole et al. (1997); Cole (2005) and Galeotti et al. (2006)). An important insight on the inverted U-shaped relationship could be the allocation of more monetary resources towards efforts for controlling environmental degradation. It might also be given intuitively that linearity of the relationship is mainly due to unavailability or lower allocated funds towards controlling pollution. Other reason is an inefficient utilization

of available funds or lack of coordinated efforts at national levels resulted in the potential failure in attaining the objectives of global community to control global environmental issues. Various econometric techniques have been implemented to investigate the relationships either in a bi-variate setting or a multivariate framework. Studies utilizing the bi-variate framework to examine the relationship between CO<sub>2</sub> emissions and economic growth include Erol and Yu (1987); Yu and Choi (1985); Akarca and Long (1980) and Bentzen and Engsted (1993). Stern (1993); Soytas and Sari (2009); Oh and Lee (2004); Ghali and El-Sakka (2004) and Narayan and Smyth (2007) have utilized multivariate framework in inquiries into the nexus. Also there exist studies employing Ordinary Least Squares to identify the true type of relationship between CO<sub>2</sub> emissions and economic growth (Friedl and Getzner, 2003).

Few studies have investigated the relationships utilizing modern time series techniques to test cointegration relationship and test the Granger causality. These techniques include vector autoregression to identify cointegration and Granger causality, augmented vector autoregression and autoregressive distributed lagged models with inconclusive results. Few studies favour the existence of causal relationship while others refuting it, few papers provide evidence on a one-sided causality while others do conclude with a two-sided causality Gosh (2010); Halicioglu (2009); Soytas et al. (2007); Selden and Song (1994) and Soytas and Sari (2003). Furthermore the scope of research has been widened by Ang (2008), Song et al (2008) and many others to utilize relatively recently developed time series econometric techniques, autoregressive distributed lag (ARDL) models by Pesaran and Pesaran (1997); Pesaran and Smith (1998); Pesaran and Shin (1999), and Pesaran et al. (2001) to test Cointegration or existence of the long run relationships and identification of causality running in either ways.

The variables to represent environmental pollution have been questioned and many proxies have been suggested to investigate the nexus of environmental pollution, economic growth and use of energy. Out of many indicators used, CO<sub>2</sub> is the main indicator which is most commonly used in the analysis. However other than CO<sub>2</sub>, sulphur dioxide and nitrous oxide are also used for investigating the relationship between pollution and growth. Methane and other trace gases are seldom utilized as proxies for environmental pollution. One main reason for the use of emission of CO<sub>2</sub> as a proxy to measure environmental degradation is its relative contribution in the pollution in terms of contaminated gasses as a result of economic growth and consumption of resources to foster growth rates. CO<sub>2</sub> comprises around 60% of all the global GHG emissions so it is one of the reliable estimates of global environmental degradation adopted by empirical investigators in the areas of Ecological, Energy and

Environmental Economics. The current paper also uses CO<sub>2</sub> as a proxy for the environmental pollution for Pakistan and is derived from World Development Indicators by World Bank (2010).

Influential papers analysing the EKC from Pakistani context usually included main determinants of the environmental pollution, energy consumption and economic growth. Alam and Butt (2002) showed that bidirectional causality exists between energy use and economic growth in Pakistan. Shahbaz et al (2011) have included financial development to assess the impact on energy consumption and emissions, showing that the effect of financial development being negative on the environmental degradation. It is mainly due to the impact of financial development as a result of financial reforms stimulating foreign direct investment and research and development. End result is economic development spelling over from higher investment and research productivity. Industrial development led economic growth results stimulates urbanization by internal migration due to agricultural mechanization leading to higher productivities. It results in rural unemployment which is absorbed in the urban industries. Higher growth of the urban populations as documented by Alam et al (2007), mainly due to employability in the urban regions, due to industrialization, compared to rural areas where traditional agricultural practices leaves masses of labour free to work in industries. Thus agriculture and industrial growth lead economic development on one hand and push the urbanization rates on the other hand (Levis, 1954; Ndulu, 1991 and Rangarajan, 1982).

### **3. Econometric Strategy**

Cointegration and Error Correction Models (ECM) are commonly applied to check for the presence of long run relationships in time series data before testing for Granger causality in levels or first differences. If the included variables are integrated of order one i.e.  $I(1)$  and have no cointegration, vector autoregression is carried out in first differences of the variables, while ECM is applied to  $I(1)$  variables (Zhang & Cheng, 2009). Current study follows Toda-Yamamoto (1995) to test Granger causality using augmented vector autoregression approach, based on the argument that it is independent of the cointegration behaviour of the time series data. Sims et al. (1990) have shown that implementation of the VAR in levels is valid for inferences, but the modus operandi depends on pre-testing the time series for existence of Cointegration. The inferences based on the procedure will not be valid when the time series are integrated or  $I(d)$  is of mixed orders. On the other hand TY procedure tests Granger causality without prior testing for cointegration. Advantage of using TY approach is its

feedback effects through inclusion of several lags into the system (Soytas et al., 2007: pp. 485).

Initially, the following VAR ( $k$ ) model is estimated.

$$X_t = a_0 + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \dots + \beta_k X_{t-k} + \eta + \varepsilon_t \quad 1 \leq t \leq T \quad (1)$$

where  $X_t$  is the vector containing ( $co_t, gdp_t, sqgdp_t, en_t, tr_t, trac_t, agr_t, ind_t, urp_t$ ). CO2 emissions in the study is in kilo tonnes ( $kt$ ),  $gdp_t$  is gross domestic product (GDP) in constant prices at 2000 level and in Pakistani Rupees (PKR),  $sqgdp_t$  is the square of  $gdp_t$  and is in the same units as GDP,  $en_t$  is energy use measured in  $kt$  of oil equivalent,  $tr_t$  is the ratio of total trade to GDP in 2000 level of PKR and is the sum of exports and imports,  $ind_t$  is the industrial value addition to proxy industrial growth,  $agr_t$  is agriculture value addition to proxy agricultural growth and  $urp_t$  is the rate of urbanization and is measured as the ratio of growth rates of urban and rural population on the assumption that both the population increases follow the national growth and higher growth in urban population is due to internal migration results relatively higher growth in urban population. The  $\varepsilon_t$  is the error term in the regression model. Lower case letters represent the terms in natural logarithms in Eq. (1).

Prior to test the Granger causality using Toda and Yamamoto (1995) Approach, the presence of long run relationship is tested using Johansen maximum likelihood approach to cointegration. Engle and Granger (1987) stated in their seminal paper that ‘‘causality of the cointegration type will not be captured by a Granger test. Therefore it should not be regarded as generally appropriate’’. So the paper first establishes cointegrating equations among the included parameters and then proceeds to test the Granger causality. Johansen and Juselius (1990) favour the maximum likelihood method as more appropriate in a multiple variable case. The number of cointegrating equations is determined by maximal eigenvalue and the trace statistic as Johansen defines it by ‘‘ $r$ ’’ or more cointegrating equations. Johansen model is given by the following equation.

$$\Delta x_t = a_0 + \Pi x_{t-1} + \sum_{i=1}^k \theta_i \Delta s_{t-i} + \mu_t \quad 1 \leq t \leq T \quad (2)$$

where  $X_t$ , as defined is the column vector of included variables,  $\Pi$  and  $\theta$  are matrices of identifiable parameters and  $\mu_t$  is the random error term. Traditionally,  $\Pi$  is dichotomized into two  $m \times r$  ordered matrices  $\Omega$  and  $\sigma$ . The hypothesis in its reduced form is  $H(r): \Pi = -\Omega\sigma^T$ , where the  $r$  linear combinations as represented by  $\sigma$  of  $\sigma^T X_t$  are stationary and error



correction parameter is represented by  $\Omega$ . Johansen approach tests the two null hypotheses of at most  $r$  cointegrating vectors and null hypothesis of  $r$  cointegrating vectors against the alternative of  $(r + 1)$  cointegrating vectors are used and represented respectively by two LM test called the trace statistic test and maximum eigenvalue test. The determination of cointegrating equations and error correction model weekly provides evidence of causality, but formally causality is tested using the TY approach.

TY procedure requires estimating the VAR model augmented with  $\theta$  the order of integrations (d) of the included time series indicators; hence identification of the order of integration (d) is necessary before proceeding to estimate the augmented VAR in generalised variance decompositions and testing for Granger causality. Unit root tests by Dickey and Fuller (1979) (ADF), Phillips and Perron (1988) (PP), Elliott et al. (1996) (DFGLS) and Kwiatkowski et al. (1992) (KPSS) are commonly applied to identify the order of integration  $I(d)$ . Current study follows various versions of the above mentioned tests to determine true order of integration.

When the true order of integration is identified, VAR (k) is estimated with augmentations (d), as an augmented vector autoregressive system VAR(k + d). If the estimated VAR(k + d) fulfils robustness criteria and passes applicable diagnostic tests, Granger causality tests are carried out on the first  $k$ -lags of the augmented VAR. The diagnostic tests include Breusch–Godfrey’s (BG) and White’s tests are applied to check heteroscedasticity and are complemented by correlograms of residuals and squared residuals. Jarque–Bera (JB) tests are applied to test normality and the Lagrange multiplier test for autoregressive conditional heteroscedasticity (ARCH LM). Parameter instability is tested using Ramsey’s RESET tests; while CUSUM and CUSUM of squares approaches of Brown et al. (1975) are implemented to test normality of the system while Chow breakpoint tests are used to test robustness of the complete VAR system.

When the proposed VAR(k + d) is found valid via the above tests, Granger causality is tested using Wald tests on the first  $k$ -lags of the system. The testing procedure is applied for each equation in the system. The hypothesis of no Granger causality is rejected if the Wald statistic is found significantly different from zero at common levels of significance. Technically speaking rejection of the  $H_0 : \beta_1 = \beta_2 = \dots = \beta_k = 0$  against  $H_1 : \beta_1 \neq \beta_2 \neq \dots \neq \beta_k \neq 0$  for any independent variable from  $(co_t, gdp_t, sqgdp_t, en_t, tr_t)$  of the VAR(k + d) implies rejection of the null of no Granger causality, or that the dependent variable from that specific equation of the VAR(k + d) system is Granger caused by the

independent variable from the list of  $(co_t, gdp_t, sqgdp_t, en_t, tr_t, trac_t, agr_t, ind_t, urp_t)$ . Complete discussion of the results is given in the next sections.

## **4. Results and Discussions**

### **4.1. The case of Pakistan economy and environment**

Economy of Pakistan has witnessed recurring fluctuations on its economic and political forefront during the last 63 years of its economic history. The growth rate of GDP remained higher than the budgetary targets in some year and in a few years it remained well below it. The GDP of Pakistan has many fold increased. It remained at 0.91 trillion in 1972 at 2000 level of Pakistani Rupees and increased to 5.5 trillion in 2007 showing an increase of more than 6 times. It has been due to rapid growth of industrial base and an increase in agricultural production. The rapid growth of economy led Pakistan to utilize its natural resources more rapidly which has resulted in deterioration of environment which can be observed from the figures on CO<sub>2</sub> emissions. Pakistan has been in the first fifty highly emitting countries in the last few years. It has been emitting more than 8 times higher than what it was emitting in 1971. It is therefore important to investigate the long run relationship and direction of causality between growth and environmental pollution.

The consumption of energy on the other hand has increased by more than four times since 1971. Also the energy sector in Pakistan has been recorded as a major contributor towards emissions accounting for about 81% of total emissions as documented by the Ministry of Environment in 2003 to UNFCCC. It is thus debatable in context of Pakistan to check if energy use has played its potential role in stimulating economic growth. Much impetus will be provided if energy sector has been discussed in more depth with sectoral composition and its impact on economic growth. The paper is among the pioneering research in the area from Pakistan point of view which provides evidence on the role of energy sector could be better represented as growth stimulators.

Finally industrial development and agriculture growth has been the mainstay of economic development in all the countries. Economic policies are targeted towards achieving higher growth rates and policies are developed to increase the rate of growth by using modern technologies. Pakistan industrial share in economy has increased by multitude and its economic structure has changes since its inception in 1947. It is commonly known as an agrarian country but the share of industries and services has increased and the ratio of industrial growth to agriculture reveals that Pakistan is transitioning towards industrial

economies. Currently main exports from Pakistan are textiles and related industries. The manufacturing sector has been contributing towards exports and the ratio of exports is also increasing over time. In 1971 the ratio of industrial production (value addition) was

It is further notable to show that Pakistan is among the low middle income group in the World Bank economic ranking and has the 6<sup>th</sup> highest population in the world. If Pakistan needs to promote economic growth it will have to utilize its natural resources more intensively to feed its higher population already living at the low level of subsistence. It will need more energy resources to stimulate pace of economic growth. But all such growth has a positive impact on emissions of CO<sub>2</sub>, which is not a promising sign of economic development at the cost of environmental degradation and endangering lives of millions of its populations. Therefore Pakistan will have to take great care when to formulate its macroeconomic policies to promote economic growth stimulated by higher level of consumption of energy resources and avoiding polluting environment. All such macroeconomic policies are to be better formulated to feed its higher population, hence Pakistan represents a good case for understanding issues related to economic policies in context of energy and environmental economics.

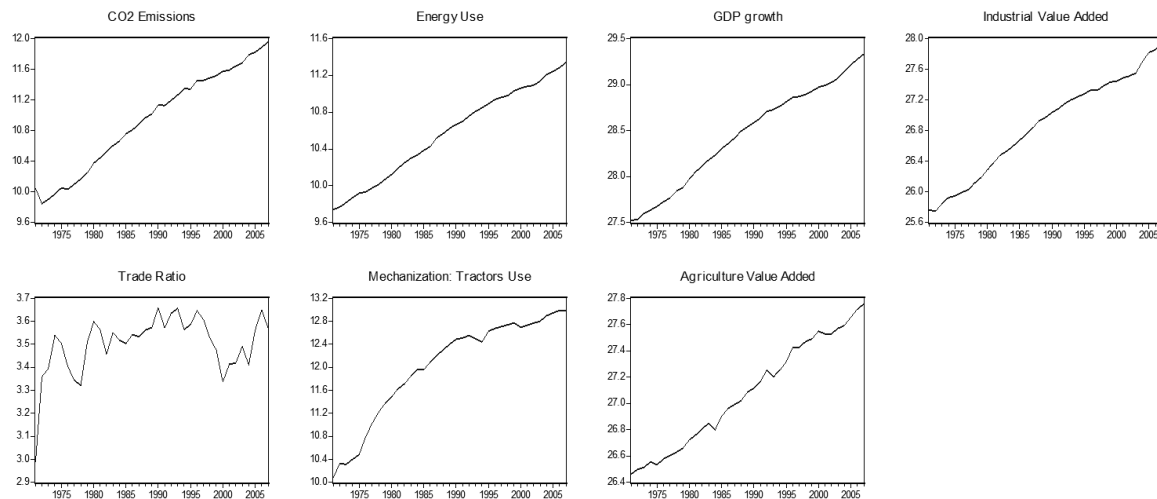
#### **4.2. Data and Time Series Properties**

Both Soytaş et al. (2007) and Friedl and Getzner (2003) showed that implementing time series techniques scales down the data in per capita measurement of the included variables. Furthermore Kyoto Protocol requires reduction in the percentage of annual total emissions rather than in per capita emissions. Also an increase in total emissions can still be visible though the level of emissions in per capita is actually decreasing as evidenced by Tisdell (2001). Thus providing evidence using data on total emissions would be an addition to the literature against Shahbaz et al (2011) and Alam et al (2007) using emissions per capita. Investigation of the causality among CO<sub>2</sub> emissions, economic growth, energy consumption, foreign trade and mechanization of agriculture is promoted in this study and control the estimated equations for growth of agriculture, industrialization and urbanization. The annual data has been derived from the World Development Indicators (World Bank, 2010) and is consistent from 1971 to 2007.

The trends in GDP growth, energy use, CO<sub>2</sub> emission, agricultural and industrial growth and ratio of population growth in urban and rural areas indicate similar patterns over time and roughly signify non-stationarity of all the series and co-movement over time, though the

pictorial analysis has its perils and needs formal testing. The small and underdeveloped countries are normally at their initial stages of economic development and a linear EKC is expected and it is the main reason the analysis is conducted utilizing a linear model. Non-linear models were estimated but these were various tests concluded the non-linear models are not stable. The results are available from authors.

**Figure 1: Pictorials of Time Series Indicators**



**Table 1: Unit root test results**

	Level		First Difference	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend
<b>GDP</b>	-1.402137(1)	-1.257847(1)	-5.081915(0)	-5.246295(0)
<b>CO2 Emission</b>	-1.07974(1)	-1.054277(1)	-10.32704(0)	-10.15246(0)
<b>Energy Use</b>	-0.852922(0)	-0.959401(0)	-4.9616(0)	-5.056846(0)
<b>Trade Ratio</b>	-3.035816(0)	-2.988928(0)	-6.118237(0)	-6.043814(0)
<b>Urbanization</b>	-1.240371(0)	-2.247925(0)	-6.038371(0)	-6.080599(0)
<b>Agriculture</b>	0.217116(0)	-3.301234(0)	-7.56703(0)	-7.528524(0)
<b>Industrialization</b>	-0.25783(0)	-3.08052(8)	-5.166799(0)	-5.169584(0)

\*, \*\* and \*\*\* present 10, 5 and 1% significance level. Values in parenthesis are lags selected. Results for Phillips and Perron (1988), Kwiatkowski et al. (1992) and Elliott et al. (1996) are available from authors.

Implementation of TY procedure is preceded by determination of order of integration of variables which is determined using common unit root tests. The augmented Dickey and Fuller (Dickey and Fuller, 1979) and the Phillips and Perron (1988) checks are implemented to test the null hypothesis that the series has a unit root. However the two tests are designed to test the null of unit roots and have a low power of rejection of the null hypothesis. To overcome the issue, a test of stationarity by Kwiatkowski et al. (1992) is implemented to test

the null of stationarity. Furthermore Elliott et al. (1996) suggest using generalized version of ADF to improve testing of the unit root in presence of a linear trend in the data. The results from Table: 1 indicate that none of the series is integrated of order higher than unity, concluding that order of integration of time series in the model is  $I(1)$  or ( $d = 1$ ). The table presents results only for ADF and tests results including Phillips and Perron (1988), Kwiatkowski et al. (1992) and Elliott et al. (1996) are available from the authors. All these unit root tests confirm the order of integration as  $I(1)$ . The order of integration of the variables confirms stationarity of time series at first differences.

After determining the maximal order of integration, the optimal number of lags for the VAR ( $k$ ) is determined by means of a combination of different information criteria including sequential modified LR test, Final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC). Table: 2 indicates that optimal lag length to be used for estimating VAR ( $k$ ) is 1 as indicated by final prediction error, Schwarz Bayesian information criteria and the Hannan-Quinn information criteria. The choice of the Schwarz Bayesian information criteria is preferred to select the optimal lag length as it selects the most parsimonious model which is desirable in case of finite small samples. The results conclude to augment the VAR ( $k = 1$ ) by  $I(d = 1)$ , leading to final system of VAR ( $k + d = 2$ ). Estimating and testing for robustness of VAR ( $k + d = 3$  or above) is not stable, hence we proceed to test Granger causality using VAR ( $k + d = 2$ ).

**Table 2: Lag length selection criteria**

lag	LL	LR	FPE	AIC	HQIC	SBIC
0	328.103		1.50E-17	-18.8884	-18.7813	-18.5742
1	550.022	443.84	6.0e-22*	-29.0601	-28.2028*	-26.5461*
2	595.792	91.539	1.10E-21	-28.8701	-27.2626	-24.1563
3	664.548	137.51*	1.20E-21	-30.0322*	-27.6745	-23.1187

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

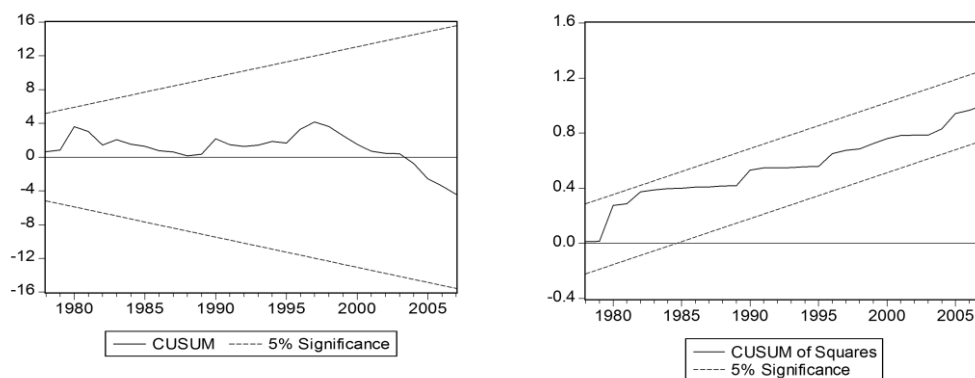
SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

The VAR(2) is subjected to different tests to check its robustness. As the results from Table: 4 indicate the augmented VAR (2) passes all the tests except energy equation where the B-G

tests indicates serial correlation at 10% significant level but it is free from such issues at 5 or 1% level of significance. The results from the autocorrelation and partial autocorrelation also indicate no signs of serial correlation. The normality of equations is tested using Jarque–Bera (J-B) test and there is no violation of normality conditions. Conventional tests were used to test the robustness of the estimated VAR system and the results confirm that there are no problems of heteroscedasticity, autocorrelation and normality violation. A Ramsey RESET test confirms no equation has any issue of instability. Results of Brown et al. (1975) proposed CUSUM and CUSUM of square tests given in Figure: 2 indicate no instability issues for the selected VAR. All the results, suggest proceeding with the estimation of the Granger causality on the first ( $k = 1$ ) lags of VAR ( $k + d = 2$ ).

**Figure 2: Plot of Cumulative Sum and Cumulative Sum of Square of Recursive Residuals**



#### 4.3. Cointegration and Granger Causality Results:

Johansen cointegration tests are conducted using the selected lag length for the VAR system which is estimated using the lag length of [1 2] based on the Schwarz Bayesian Criteria which supports selecting the most parsimonious model desirable when the finite samples. The stability of the selected system is checked using the AR Roots of a Characteristic Polynomial. The results indicate that the selected lag length is satisfactory and VAR system could be used for estimating cointegration and Granger causality. The existence of cointegration is confirmed using the Johansen maximum likelihood estimation of cointegration testing. The results in Table (2) indicate there are 5 cointegrating equations using Trace statistic and 3 equations using the Maximum Eigenvalue statistic, hence it is concluded that there are 5 cointegrating equations at maximum. The estimated cointegrated equations confirm long run causality among the time series. The paper provides evidence on these causal relations using the Granger causality testing based on the modified Wald statistic and Block exogeneity test and also from pairwise Granger causality testing. Pairwise granger causality results are included in the Table (3). After determination of the existence of the cointegration

relationship, the granger causality tests are carried out using the block exogeneity and pairwise tests.

**Table 3: Johansen Maximum Likelihood Cointegration Test**

Hypothesized no. of co-integrating equations	Max. Eigenvalue	Trace Statistic
<b>None</b>	77.83531*	228.9879*
<b>At most 1</b>	48.04264*	151.1526*
<b>At most 2</b>	47.71297*	103.1099*
<b>At most 3</b>	24.71517	55.39696*
<b>At most 4</b>	15.90399	30.68179*
<b>At most 5</b>	13.49806	14.77781
<b>At most 6</b>	1.279745	1.279745

*MacKinnon-Haug-Michelis (1999) p-values*

Confirmation of cointegration relation suggests to safely proceeding to test Granger cause relationship among the time series. Table: 4 indicate bidirectional Granger causality between (economic growth and Carbon Dioxide emissions), (energy consumption and economic growth), (agriculture growth and economic growth), (industrial growth and economic development) and (emissions and emissions and industrial growth). Further, bidirectional Granger causality is also exists between industrial growth and urbanization. On the other hand, a unidirectional Granger causality exists between (energy consumption and emissions),(foreign trade and emissions), (foreign trade and industrial growth) and (urbanization and emissions) and (urbanization and economic growth). The results are in contradicts to the findings of Zhang and Cheng (2009) for China implying that Government of Pakistan will need to implement carefully the conservative energy policy and need to promote efficient use of energy resources in the long run without compromising on reduction of growth of GDP. However the results are similar to the findings of Soytaş and Sari (2006) and Yuan et al. (2008). Contrary to China, findings of the current research in Pakistan indicate that, an increase in GDP will lead to higher levels of consumption of energy and results in higher emissions, thus Pakistan needs to use efficiently energy resources and will have to produce alternative resources which has lower emitting levels. Evidence on sectoral energy consumption and production and environmental pollution will provide support to this finding in case if more electricity is generated using oil and thermal resources. It implies Pakistan will need to produce strong and lower emitting energy base for its future when its masses have higher level of living with higher demand for power and other energy resources.

**Table 4: Granger causality/Block exogeneity results**

	CO	GDP	EN	TR	AGR	IND	URP
CO		12.78**	3.77	0.72	7.92**	10.87**	3.86
GDP	25.96***		4.97*	0.73	1.57	3.16	4.60
EN	10.33**	9.00**		0.59	1.74	15.07***	2.35
TR	8.95**	0.60	1.57		2.99	0.78	5.32*
AGR	5.34*	9.96**	0.60	2.48		1.84	0.39
IND	8.83**	1.82	4.20	3.68	2.40		7.80**
URP	14.05***	42.96***	4.13	3.01	3.34	19.01***	

\*, \*\* and \*\*\* denotes significance at 1, 5 and 10% levels. Null hypothesis tests that the Row variable Granger causes column variables

Furthermore the pairwise Granger causality is conducted to check the bivariate causality using the modified VAR system which assumes the variables of interest being endogenous and the set of other variables be exogenous into the system. The results differ from the Block exogeneity evidence in Table (4). The results in Table (5) confirm the bivariate/pairwise Granger causality

**Table 5: Pairwise Granger causality results**

	CO	GDP	EN	TR	IND	AGR	URP
CO		0.20868	2.11981	0.87701	1.11679	4.94530**	1.11465
GDP	14.3270***		6.92047**	3.75493*	2.55755*	3.72857**	0.82891
EN	3.31977**	1.07900		1.23535	1.11102	5.86393**	0.59933
TR	0.52283	0.55502	0.40115		1.04118	1.17657	2.22139
IND	6.20930**	1.07343	5.26576**	5.00435**		4.28587**	0.63284
AGR	0.25016	1.53343	1.32833	1.63475	0.01616		0.73638
URP	5.82964**	4.54683**	3.36119**	0.56448	3.89706**	3.33437**	

\*, \*\* and \*\*\* denotes significance at 1, 5 and 10% levels. Null hypothesis tests that the Row variable Granger causes column variables

Consumption of energy is observed to Granger cause CO<sub>2</sub> emissions at 1% level of significance. It suggests that higher consumption of energy leads to higher emissions of CO<sub>2</sub> in Pakistan but the reverse is not the case. It indicates that in Pakistan should effectively develop and implement policies to reduce CO<sub>2</sub> emissions without compromising on the consumption of energy and GDP as it is suggested that CO<sub>2</sub> emissions have no effect on consumption of energy and GDP in the long run. It demands more effective policy making



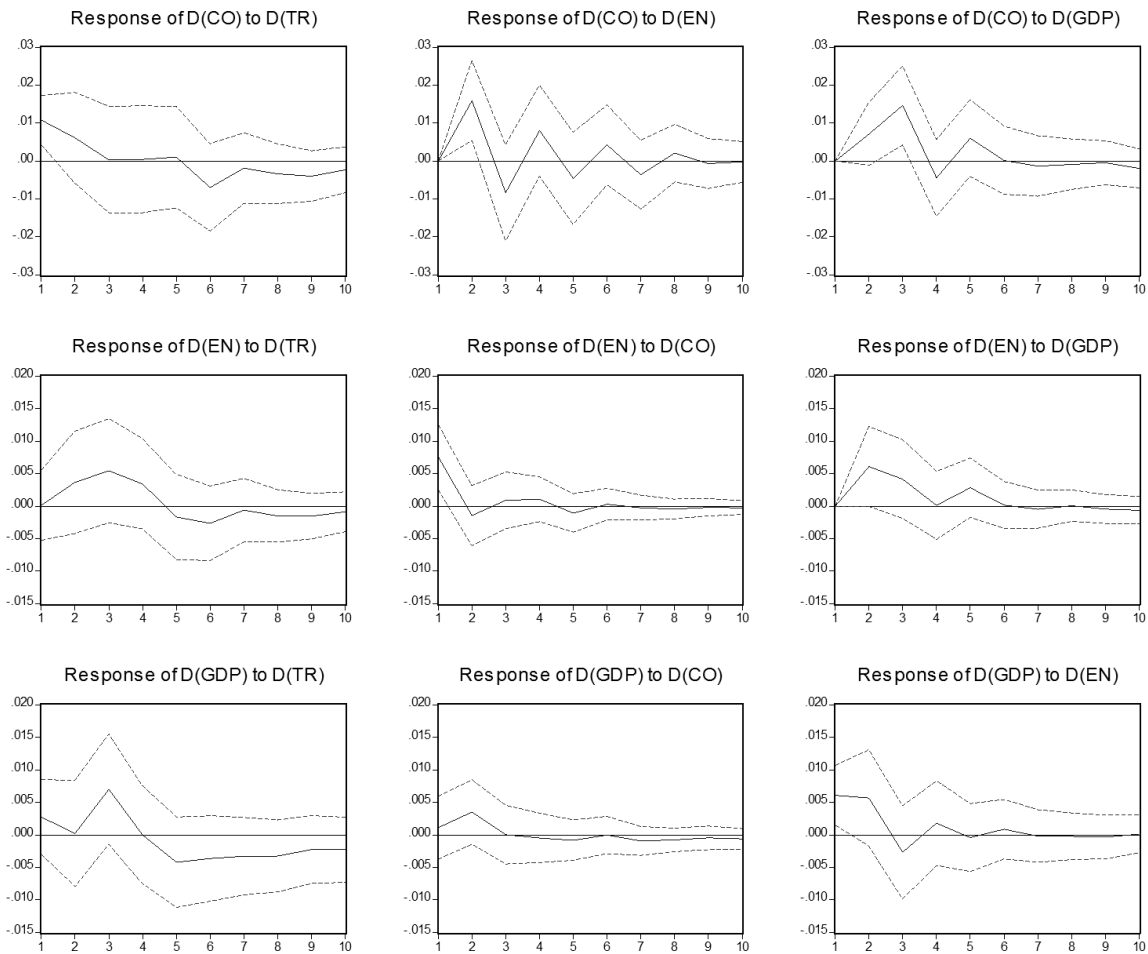
and implementation strategies that really affects CO<sub>2</sub> emissions. An alternative policy option can be the environmental taxation where pollution specific taxation could lead to a reduction of CO<sub>2</sub> emission but it requires identification of highly emitting organizations and/or corporations which have implemented lower control measures to reduce gaseous emissions. In underdeveloped countries such policy measures are not less than a challenge. The findings motivate a detailed investigation of the industry or firm specific factors leading to higher emissions in Pakistan to suggest industry or firm specific remedies to check environmental degradation and other related issues. Furthermore results of the paper confirm findings of the Soyatas et al. (2007) in contradiction to the results of Soyatas and Sari (2009).

#### **4.4. Generalized Impulse Responses:**

Granger causality test for the variables lack provision of evidence on the responses in variables to changes in other variables. The impulse response functions could be utilized to observe the impact of shocks in one variable on the other variables beside to see whether the effects persists over longer time period or dies down quickly. Koop et al. (1996) and Pesaran and Shin (1998) suggested to implement generalized impulse responses and generalized variance decomposition to evaluate the impact of impulse in one variable on other variables. It overcomes the orthogonality problems commonly identified in the classical Granger causality testing. The detailed graphical results of impulse responses of one standard deviation are presented in Figure: 3.

The graphical representation of the generalized impulse responses indicates that an innovation in GDP and consumption of energy does not affect emissions significantly while trade openness has a significant initial impact on the CO<sub>2</sub> emissions. Surprisingly the impact of trade openness on CO<sub>2</sub> emissions is not only highly significant but also lasts for a longer period than the impact of innovations in GDP and consumption of energy, while it has been identified previously in the same research that trade openness does not Granger causes CO<sub>2</sub> emissions in Pakistan. The response functions for GDP and consumption of energy indicates that an impulse in CO<sub>2</sub> leads to a significant initial impact lasting for a longer time period. However the impact on GDP decays slowly than the impact on energy consumption. Innovations in GDP leads to a insignificant initial response from the consumption of energy that gradually decays down over a longer time period than the vice versa.

**Figure 3: Impulse Responses Functions**



*Note: Impulse response tables can be requested from the author. Results on Impulse Response functions for level variables can be acquired from the authors. Variables are in first differences.*

It is observed that trade openness initially has also a significant impulse over the GDP. Finally the response of trade openness is insignificant to innovations in energy consumption while it impulses significantly to the innovations in GDP.

## **5. Conclusions and Policy Suggestions**

The findings of the research indicate that GDP is the major cause of long run changes in the CO<sub>2</sub> emissions and energy consumption in Pakistan. Data is obtained from the World Development Indicators of World Bank and consistent from 1971 to 2007. The two-way causal relation between GDP and CO<sub>2</sub> emissions and a one-way causal relation between emissions and energy consumption suggests that Government of Pakistan need to implement policy motivating efficient use of energy resources to control environmental degradation and

hence contributing less than its current levels to the global warming. The results also convince that when Government of Pakistan will implement policies to control environment degradation, it can utilize its industrial and agricultural policies which also cause emission of CO<sub>2</sub> in the long to change. Also an important piece of evidence comes up from the results that industrial and agriculture growth does not change Pakistan's international trade, rather Pakistan produces those outputs which causes higher emissions, hence Pakistan need to emphasize on exporting those products which with low level of emission.

The results further indicate that in Pakistan, foreign trade has long run linkages with the GDP where a unidirectional Granger causality runs from GDP to international trade openness. The economic history of Pakistan shows that agriculture sector has significantly contributed to total GDP and is significantly contributes to exports earnings. Future research on the causal relationships between environmental degradation in either form should be conducted to identify sectoral contributions to GDP and through to CO<sub>2</sub> emissions and other types of environmental degradation. One important suggestion in this regard comes up in the form of analysis of the long run relationship of between growth of textile sector, consumption of fertilizer in textile sector, its contribution to GDP and international trade. Evidently it will provide important policy insights to base economic and environmental policies in Pakistan even more effectively when sector efforts are initiated where the sectors contribute more to emissions. Furthermore it is also suggested that if Government of Pakistan implement environmental taxation, it could motivate efficient consumption of energy resources and will help in lowering lavish consumption of energy resources due to higher taxation on higher consumption which have no negative consequences for economic growth in the long run.

Lastly it is suggested from the research that a disaggregation of environmental and macroeconomic indicators could further provide insights to identify specific economic forces contributing to CO<sub>2</sub> emissions. The advantage of policies based on findings from disaggregation might be a support for effective policies compared to policies based on findings from general research. Also such policies could be implemented to account for technical change which can result in more efficient uses of energy resources and reduce its negative impact of higher use of energy on environment. The manufacturers of electrical and other appliances has started introducing new environment friendly and energy conservative products contributing positively towards saving environment via reducing the impact of energy on CO<sub>2</sub> and other contaminated emissions.

## 6. References

- Aboosedra, S., Baghestani, H., 1989. New evidence on the causal relationship between United States energy consumption and gross national product, *Journal of Energy and Development* 14, 285–292.
- Akarca, A.T., Long, T.V., 1980. On the relationship between energy and GNP: a re-examination, *Journal of Energy and Development* 5, 326–331.
- Alam, S., & Butt, M. S. (2002). Causality between energy and economic growth in Pakistan: An application of cointegration and error correction modeling techniques. *Pacific and Asia Journal of Energy*, 12(2), 151–165.
- Alam, S., Fatima, A. and Butt, M.S., (2007). Sustainable development in Pakistan in the context of energy consumption demand and environmental degradation, *Journal of Asian Economics* 18 (2007) 825–837
- Ang, J. B., 2008. Economic development, pollutant emissions and energy consumption in Malaysia, *Journal of Policy Modeling* 30(2), 271-278
- Ang, J.B., 2007. CO<sub>2</sub> emissions, energy consumption, and output in France, *Energy Policy* 35, 4772–4778.
- Azomahou, T., Laisney, F., Phu, N.V., 2006. Economic development and CO<sub>2</sub> emissions: a nonparametric panel approach, *Journal of Public Economics* 90, 1347–1363.
- Bentzen, J., Engsted, T., 1993. Short- and long-run elasticities in energy demand, *Energy Economics* 15, 9–16.
- Boden, T.A., Marland, G. and Andres, R.J. 2010. Global, Regional, and National Fossil-Fuel CO<sub>2</sub> Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001\_V2010
- Brown, R.L., Durbin, J., Evans, J.M., 1975. Techniques for testing the constancy of regression relations over time, *Journal of the Royal Statistical Society* 37, 149–163.
- Cole, M.A., 2005. Re-examining the pollution–income relationship: a random coefficients approach, *Economics Bulletin* 14, 1–7.
- Cole, M.A., Rayner, A.J. and Bates, J.M., 1997. The environmental Kuznets curve: an empirical analysis. *Environ. Devel. Econ.* 2 4, 401–416.
- Coondoo, D., Dinda, S., 2008. The carbon dioxide emission and income: a temporal analysis of cross-country distributional patterns, *Ecological Economics* 65, 375–385.

- Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Society* 75, 427–431.
- Dickey, D.A., Fuller, W.A., 1981. Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica* 49, 1057–1072.
- Dinda, S., Coondoo, D., 2006. Income and emission: a panel data-based cointegration analysis, *Ecological Economics* 57, 167–181.
- Elliott, G., Rothenberg, T.J., Stock, J.H., 1996. Efficient tests for an autoregressive unit root, *Econometrica* 64, 813–836.
- Erol, U., Yu, E.S.H., 1987. On the causal relationship between energy and income for industrialized countries, *Journal of Energy and Development* 13, 113–122.
- Friedl, B., Getzner, M., 2003. Determinants of CO<sub>2</sub> emissions in a small open economy, *Ecological Economics* 45, 133–148.
- Galeotti, M., Lanza, A., 1999. Desperately seeking environmental Kuznets. Mimeo, International Energy Agency, Paris.
- Galeotti, M., Lanza, A., Pauli, F., 2006. Reassessing the environmental Kuznets curve for CO<sub>2</sub> emission: a robustness exercise, *Ecological Economics* 57, 152–163.
- Ghali, K.H., El-Sakka, M.I.T., 2004. Energy use and output growth in Canada: a multivariate cointegration analysis, *Energy Economics* 26(2), 225–238.
- Ghosh, S., 2010. Examining carbon emissions economic growth nexus for India: a multivariate cointegration approach, *Energy Policy*, 38(6), 3008-3014.
- Grossman, G., Krueger, A., 1995. Economic environment and the economic growth. *Quarterly Journal of Economics*, 110, 353–377
- Halicioglu, F., 2009. An econometric study of CO<sub>2</sub> emissions, energy consumption, income and foreign trade in Turkey, *Energy Policy* 37, 1156–1164.
- He, J., and Richard, P., 2010. Environmental Kuznets curve for CO<sub>2</sub> in Canada, *Ecological Economics*, 69(5), 1083-1093
- Holtz-Eakin, D., Selden, T.M., 1995. Stoking the fires? CO<sub>2</sub> emissions and economic growth, *Journal of Public Economics* 57, 85–101.
- Karl, T.R., Kukla, G., Razuvayev, V.N., Changery, M.J., Quayle, R.G., Heim, R.R. Jr., Easterling, D.R., Fu, C.B., 1991. Global warming: Evidence for asymmetric diurnal temperature change. *Geophys. Res. Lett.* 18, 2253–2256
- Kraft, J., Kraft, A., 1978. On the relationship between energy and GNP, *Journal of Energy Development* 3, 401–403.

- Kuznets, S., 1955. Economic growth and income inequality, *American Economic Review* 45, 1–28.
- Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., Shin, Y., 1992. Testing the null hypothesis of stationary against the alternative of a unit root, *Journal of Econometrics* 54, 159–178.
- Managi, S., Jena, P.R., 2008. Environmental productivity and Kuznets curve in India, *Ecological Economics* 65, 432–440.
- Martinez-Zarzoso, I., Bengochea-Morancho, A., 2004. Pooled mean group estimation for an environmental Kuznets curve for CO<sub>2</sub>, *Economic Letters* 82, 121–126.
- Masih, A.M.M., Masih, R., 1996. Energy consumption, real income and temporal causality: Results from a multi-country study based on cointegration and error-correction modelling techniques, *Energy Economics* 18, 165–183.
- Mongelli, I., Tassielli, G., Notarnicola, B., 2006. Global warming agreements, international trade and energy/carbon embodiments: an input-output approach to the Italian case, *Energy Policy* 34, 88–100.
- Moomaw, W.R. and Unruh, G.C., 1997. Are Environmental Kuznets Curves misleading us? The case of CO<sub>2</sub> emissions. *Environ. Dev. Econ.* 2(4), 451–463.
- Narayan, P.K., Narayan, S., Smyth, R., 2008. Are oil shocks permanent or temporary? Panel data evidence from crude oil and NGL production in 60 countries, *Energy Economics* 30(3), 919–936.
- Narayan, P.K., Singh, B., 2007. The electricity consumption and GDP nexus for the Fiji Islands, *Energy Economics* 29, 1141–1150.
- Narayan, P.K., Smyth, R., 2007. Are shocks to energy consumption permanent or temporary? Evidence from 182 countries, *Energy Policy* 35(1), 333–341.
- NOAA National Climatic Data Center, 2010. State of the Climate: Global Analysis, retrieved from <http://www.ncdc.noaa.gov/sotc/global/2010/1>.
- Oh, W., Lee, K., 2004. Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999, *Energy Economics* 26, 51–59.
- Pesaran, M.H., Pesaran, B., 1997. *Working With Microfit 4.0: Interactive Econometric Analysis*, Oxford University Press, Oxford .
- Pesaran, M.H., Shin, Y., 1999. An autoregressive distributed lag modelling approach to cointegration analysis. In: S. Storm, Editor, *Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium*, Cambridge University Press, Cambridge, 1–31 Chapter 11.

- Pesaran, M.H., Shin, Y., Smith, R., 2001. Bounds testing approaches to the analysis of level relationships, *Journal of Applied Econometrics* 16, 289–326.
- Pesaran, M.H., Smith, R.P., 1998. Structural analysis of cointegrating VARs, *Journal of Economic Survey* 12, 471–505.
- Roca, J., Padilla, E., Farré, M., Galletto, V., 2001. Economic growth and atmospheric pollution in Spain: discussion the environmental Kuznets next term hypothesis, *Ecological Economics* 39, 85–99.
- Selden, T.M., Song, D., 1994. Environmental quality and development: is there a Kuznets curve for air pollution?, *Journal of Environmental Economics and Management* 27, 147–162.
- Shafik, N., Bandyopadhyay, S., 1992. Economic growth and environmental quality, Background Paper for the 1992 World Development Report, The World Bank, Washington, DC.
- Sims, C., Stock, J., Watson, M., 1990. Inference in linear time series models with unit roots, *Econometrica* 58, 113–144.
- Song, T., Zheng, T.G., Tong, L.J., 2008. An empirical test of the environmental Kuznets curve in China: a panel cointegration approach, *China Economic Review* 19, 381–392.
- Soytas, U., Sari, R., 2003. Energy consumption and GDP: causality relationship in G-7 countries and emerging markets, *Energy Economics* 25, 33–37.
- Soytas, U., Sari, R., 2006. Energy consumption and income in G-7 countries, *Journal of Policy Modeling* 28 (7), 739–750.
- Soytas, U., Sari, R., 2009. Energy consumption, economic growth, and carbon emissions: challenges faced by an EU candidate member, *Ecological Economics* 68, 1667–1675.
- Soytas, U., Sari, R., Ewing, B.T., 2007. Energy consumption, income, and carbon emissions in the United States, *Ecological Economics* 62, 482–489.
- Stern, D.I., 1993. Energy use and economic growth in the USA: a multivariate approach, *Energy Economics* 15, 137–150.
- The World Bank, 2010. The World Development Indicators 2010, (WDI) Database.
- Toda, H.Y., 1995. Finite sample performance of likelihood ratio tests for cointegrating ranks in vector autoregressions, *Econometric Theory* 11, 1015–1032.
- Toda, H.Y., Yamamoto, T., 1995. Statistical inference in vector autoregression with possibly integrated processes, *Journal of Econometrics* 66, 225–250.
- United Nations Population Division. 2010. World Population Prospects: The 2007 Revision. New York, NY: United Nations.

- Watson, R.T., Zinyowera, M.C., Moss, R.H., Eds., 1995. Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses, Second Assessment Report of the Working Group II for InterGovernmental Panel on Climate Change (IPCC)
- Wolde-Rufael, Y., 2009. Energy consumption and economic growth: the experience of African countries revisited, *Energy Economics* 31(2), 217–224.
- Wyckoff, A.M., Roop, J.M., 1994. The embodiment of carbon in imports of manufactured products: implications for international agreements on greenhouse house gas emissions, *Energy Policy* 22, 187–194.
- York, R., Rosa, E.A., Dietz, T., 2003. STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmentalnext term impacts, *Ecological Economics* 46, 351–365.
- Yu, E.S.H., Choi, J.Y., 1985. The causal relationship between energy and GNP: an international comparison, *Journal of Energy and Development* 10, 249–272.
- Yuan, J.H., Kang, J.G., Zhao, C.H., Hu, Z.G., 2008. Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels, *Energy Economics* 30, 3077–3094
- Zhang, X.P., Cheng, X.M., 2009. Energy consumption, carbon emissions, and economic growth in China, *Ecological Economics* 68(10), 2706–2712.
- Zivot, E., Andrews, D., 1992. Further evidence of the great crash, the oil-price shock and the unit-root hypothesis, *Journal of Business and Economic Statistics* 10, 251–270.