Environmental Kuznets Curve and the Role of Energy Consumption in Pakistan

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Abstract

The paper is an effort to fill the gap in the energy literature with a comprehensive country study for Pakistan. We investigate the relationship between CO2 emissions, energy consumption, economic growth and trade openness for Pakistan over the period of 1971-2009. ARDL model for cointegration and Granger causality tests are employed for the analysis. The result suggests that there exists long run relationship among the variables. The EKC hypothesis is supported in the country. Furthermore, we find one-way causal relationship running from income to CO2 emissions. Energy consumption increases CO2 emissions both in short and long run. Openness to trade reduces CO2 emissions in long run but it is insignificant in short run.

1. Introduction

In any economy, sustainable economic development can be achieved by sustainable environment development. The government of Pakistan launched an environmental policy in 2005 to control environmental degradation with sustained level of economic growth. The main objective of the National Environmental Policy (NEP) is to protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development. Meanwhile, the economic growth is stimulated by all sectors of economy including agricultural, industrial and services. The rising growth rate in Pakistan is lead by industrial sector generally and manufacturing sector particularly in contributing the national accounts[1]. This industrial-led growth increases energy demand and resulting environmental pollutants increase in the country. In 2002-2003, industrial sector consumed 36% of total energy consumption while 33% is consumed by transportation. Even though total energy consumption is declined to 29% in 2008-2009, but the consumption by industrial sector has increased to 43% over the period[2].

For the case of Pakistan, high usage of petroleum to meet transportation demand is a major reason of CO2 emissions[3]. A considerable share of CO2 emissions is coming from natural gas mainly by the electricity production and coal consumption produces more than 50% of CO2 emissions of natural gas. In 2005, 0.4% of the world total CO2 emissions were produced by Pakistan and this “contribution” is worsening day by day. While the income per capita has increased from PRS 32,599 to PRS

[1] In 2009, economic growth rate is 2% due to poor performance of the industrial and manufacturing sectors (Economic Survey of Pakistan, 2008-2009).
[2] Economic Survey of Pakistan, 2008-2009, p. 226.
[3] The nature of transportation has been converted to compressed gas consumption after hike in petroleum prices.

36,305 over 2006-2009, the usage of energy per capita was increased from 489.36 (kg of oil equivalent) in 2006 to 522.66 (kg of oil equivalent) in 2009. This has led CO2 emissions per capita rise from 0.7657 metric tons to 1.026 metric tons over the period of 2006-2009.

The theory of environmental Kuznets curve (EKC) reveals that environmental degradation increases at initial level of sustainable development and starts to decline as economy achieves high level of economic development. This relationship between environmental degradation and economic growth is term as inverted U-shaped curve. The estimable relationship between environmental degradation and income per capita has been empirically investigated to some extent but no study is found for the case of Pakistan.

On the other hand, globalization leads to greater integration of economies and societies (Agenor, 2003). Thus, new trade routes have been discovered and technology of transport has been improved to obtain benefits from openness. The Hecksher-Ohlin (Hecksher, 1919 and Ohlin, 1933) model posits that differences in labour productivity lead to produce different goods in different economies. Trade is a main engine that provides a way to enhance production intensively by utilizing abundant domestic resources efficiently. Trade openness also provides a way for mobilizing factors of production freely between the countries. However, movement of factors of production may also move dirty industries from home countries to developing economies where laws and regulations about environment is just formality. For example, Feridun et al. (2006) documented that trade openness harms the environmental quality in less developed economies like Nigeria.

Antweiler et al. (2001) examined effect of trade on environmental quality. They introduced composition, scale and technological effects by decomposing the trade model. Their study concluded that trade openness is beneficial for environment if the technological effect is greater than the composition effect and scale effect. This shows that increasing trade will improve the income level of developing nations which induce them to import less polluting techniques to enhance the production. Copeland and Taylor (2005) supported that international trade is beneficial to environmental quality through environmental regulations and capital-labor channels. The authors documented that free trade declines CO2 emissions. The main reason is international trade will shift the production of pollution-intensive goods from developing countries to the developed nations and hence declines CO2 emissions of the world. Managi et al. (2008) found that quality of environment is improved if environmental regulation effect is stronger than capital labour effect. Similarly, McCarney and Adamowicz (2006) suggested that trade openness improves environmental quality depending on government policies. The local government can reduce CO2 emissions through the environmental policies.

The present study is an effort to fill the gap in the energy literature because there is lack of comprehensive study for Pakistan. Single country study helps policy making authorities in making comprehensive policy to control environmental degradation. This study contributes to energy literature with a case study of Pakistan using time series data for the period of 1971-2009. Moreover, an important variable, trade openness is taken into account for its impact on environmental pollution. The rest of the paper is organized as following: Literature review is explained in section 2.

Section 3 describes theoretical and estimable model. The empirical results are reported in section 4 and finally, conclusion and policy implication are drawn in section 5.

2. Literature review

The relevant literature shows two strands of link between energy consumption and CO2 emissions i.e. economic growth and CO2 emissions and, economic growth and energy consumption. The dominating relationship between economic growth and CO2 emissions has been achieved great attention of researchers. The relationship between CO2 emissions and economic growth is termed as EKC[4]. The association between economic growth and CO2 emissions reveals that economic growth is linked with high CO2 emissions initially and CO2 emissions tends to decrease as an economy achieves turning point or threshold level of economic growth.

The empirical studies of EKC started by Grossman and Krueger (1991) and followed by Lucas et al. (1992), Wyckoff and Roop (1994), Suri and Chapman (1998), Heil and Selden (1999), Friedl and Getzner (2003), Stern (2004), Nohman and Antrobus (2005), Dinda and Coondoo (2006) and Coondoo and Dinda (2008). Existing studies seem to present mixed empirical evidences on the validity of EKC. Song et al. (2008), Dhakal (2009), Jalil and Mahmud (2009) and, Zhang and Cheng (2009) supported the existence of EKC in China. The findings of Fodha and Zaghdoud (2010) revealed the existence of EKC between the SO2 emissions and economic growth but not for the CO2 emissions in Tunisia. In contrast, Akbostanci et al. (2009)

[4] The relationship is described by the linear and non-linear terms of GDP per capita in the model.

did not support the existence of EKC in Turkey. They argued that CO_2 emissions are automatically reduced due to the rapid pace of economic growth.

On the other hand, the relationship of energy consumption and economic growth has been investigated extensively as well. For example, Kraft and Kraft (1978) for USA, Masih and Masih (1997) for Taiwan and Korea, Aqeel and Butt (2001) for Pakistan, Wolde-Rufael (2006) for African, Narayan and Singh (2007) for Fiji, Reynolds and Kolodzieji (2008) for Soviet Union, Chandran et al. (2009) for Malaysia, Narayan and Smyth (2009) for Middle Eastern and Yoo and Kwak (2010) for South American concluded that energy consumption causes economic growth. Opposite causality is also found running from economic growth to energy consumption by Altinay and Karagol (2004) and Halicioglu (2009) for Turkey, Squalli (2006) for OPEC, Yuan et al. (2007) for China and Odhiambo (2009) for Tanzania. Bivariate causality between energy consumption and economic growth is also documented by Asafu-Adjaye (2000) for Thailand and Philippines.

Recent literature documented alliance of economic growth with energy consumption and environmental pollution to investigate the validity of EKC. The relationship between economic growth, energy consumption and CO_2 emissions have also been researched extensively both in the country case and panel studies. Ang (2007) found stable long run relationship between economic growth, energy consumption and CO_2 emissions for French economy while Ang (2008) also got similar result for Malaysia. Ang (2007) showed that causality is running from economic growth to energy consumption and CO_2 emissions in the long run but energy consumption causes economic growth in short run. In the case of Malaysia, Ang (2008) reported that output increases CO_2 emissions and energy consumption. Ghosh (2010) documented that no long run causality between economic growth and CO_2 emissions and bivariate short run causality in India.

For the panel studies, Apergis and Payne (2009) investigated this alliance relationship for six Central American economies using panel VECM. It is evident that energy consumption is positively linked with CO_2 emissions and EKC hypothesis has been confirmed. Lean and Smyth (2010) and Apergis and Payne (2010) reached the same conclusion for the case of ASEAN countries and Commonwealth of Independent States respectively. Narayan and Narayan's (2010) empirical evidence also validates the EKC hypothesis for 43 low income countries. In addition, Lean and Smyth (2010) noted long run causality running from energy consumption and CO_2 emissions to economic growth but in the short span of time, energy consumption causes CO_2 emissions. On the other hand, Apergis and Payne (2010) found that energy consumption and economic growth Granger causes CO_2 emissions while bivariate causality is found between energy consumption and economic growth; and between energy consumption and CO_2 emissions.

The relationship between international trade and environment has also been investigated empirically. Grossman and Krueger (1991) argued that environmental effect of international trade depend on the policies of an economy. There are two schools of thought about the impact of international trade on CO_2 emissions. One argued that trade openness provides an offer to each country to have access to international market which enhances the market share among countries. This leads the competition among the countries and increases the efficiency of using scarce resources and encourages importing cleaner technologies to decline CO2 emissions (e.g. Runge, 1994 and Helpman, 1998). Other group probed that natural resources are depleted due to international trade. This depletion of natural resources raises CO2 emissions and causes environment quality worsened (e.g. Schmalensee et al., 1998; Copeland and Taylor, 2001; Chaudhuri and Pfaff, 2002).

In country case studies, Machado (2000) indicated positive link between foreign trade and CO2 emissions in Brazil. Mongelli (2006) concluded that pollution haven hypothesis is existed in Italy. Halicioglu (2009) added trade openness to explore the relationship between economic growth, CO2 emissions and energy consumption for Turkey. The result showed that trade openness is one of main contributor to economic growth while income raises the levels of CO2 emissions. Shiyi (2009) explored this issue to Chinese provinces and documented industrial sector's development is linked with increase of CO2 emissions due to energy consumption[5].

3. Theoretical and modeling framework

Different approaches have been used to investigate the relationship between economic growth, CO2 emissions and natural resources. Jorgenson and Wilcoxen (1993) and Xepapadeas (2005) model the links between energy consumption, environment pollutants and economic growth in equilibrium framework with aggregate growth model. A recent strand of research has explored link between economic growth and CO2 emissions, and energy consumption and CO2 emissions in

[5] Zhang and Cheng (2009) concluded that GDP growth causes the energy consumption while energy consumption causes CO2 emissions.

single equation model (Ang, 2007, 2008 and Soytas et al., 2007). The present study follows the methodology applied by Ang (2007, 2008), Soytas et al. (2007), Halicioglu (2009) and Jalil and Mahmud (2009)[6].

The relationship between CO2 emissions and energy consumption, economic growth and trade openness is specified as follow:

$$CO2 = f(ENC, GDP, GDP^2, TR) \quad (1)$$

where CO2 is CO2 emissions per capita, ENC is energy consumption per capita, GDP (GDP^2) is real GDP (squared) per capita and TR is trade openness (exports + imports as share of GDP). The linear model is converted into log-linear specification as it provides more appropriate and efficient results compare to the simple linear functional form of model (see Cameron, 1994; Ehrlich, 1975, 1996). Hence, the estimable equation is re-written as follow:

$$LCO2_t = \beta_1 + \beta_{ENC} LENC_t + \beta_{GDP} LGDP_t + \beta_{GDP^2} LGDP_t^2 + \beta_{TR} LTR_t + \mu_t \quad (2)$$

μ_t is stand for residual or error term.

It is expected that economic activity is stimulated with an increase in energy consumption that in resulting increase of CO2 emissions. This leads us to expect $\beta_{ENC} > 0$. The environmental hypothesis reveals that $\beta_{GDP} > 0$ while sign of GDP^2 should be negative or $\beta_{GDP^2} < 0$. The expected sign of trade openness is negative, $\beta_{TR} < 0$ if production of pollutant intensive items is reduced due to the environment protection laws and imports such items from the other countries where environmental laws are flexible. However, Grossman and Krueger (1995) and Halicioglu (2009)

[6] Halicioglu (2009) and Jalil and Mahmud (2009) included foreign trade as an independent factor in their models to examine the impact of foreign trade on environmental pollutants.

argued that sign of β_{TR} is positive if dirty industries of developing economies are busy to produce heavy share of CO2 emissions with production.

Pesaran et al. (2001) established an advanced approach to examine cointegration among variables. This approach is termed as Autoregressive Distributive Lag (ARDL**)** bounds test. The ARDL model can be applied without investigating the order of integration (Pesaran and Pesaran, 1997). Most macroeconomic variables are integrated at I(0) or I(1). Haug (2002) argued that ARDL approach for cointegration presents better results for small sample data set as compared to other techniques for cointegration such as Engle and Granger (1987), Johansen (1990) and Philips and Hansen (1990).

Furthermore, the unrestricted error correction model (UECM) seems to take satisfactory lags that captures the data generating process in a general-to-specific framework of specification (Laurenceson and Chai, 2003). However, Pesaran and Shin (1999) contented that *appropriate modification of the orders of the ARDL model is sufficient to simultaneously correct for residual serial correlation and the problem of endogenous variables*. The UECM is being constructed to examine the long run and short run relationships among the variables.

$$\begin{aligned}\Delta LCO2_t &= \alpha_\circ + \alpha_1 T + \sum_{i=1}^{p}\beta_i \Delta LCO2_{t-i} + \sum_{i=0}^{q}\delta_i \Delta LENC_{t-i} + \sum_{i=0}^{r}\varepsilon_i \Delta LGDP_{t-i} + \sum_{i=0}^{s}\sigma_i \Delta LGDP^2_{t-i} \\ &+ \sum_{i=0}^{v}\omega_i \Delta LTR_{t-i} + \lambda_{CO2} LCO2_{t-1} + \lambda_{ENC} LENC_{t-1} + \lambda_{GDP} LGDP_{t-1} + \lambda_{GDP^2} LGDP^2_{t-1} + \lambda_{TR} LTR_{t-1} + \mu_t \end{aligned} \quad (3)$$

Equation (3) presents two segments of results. The first part indicates the short run parameters such as $\beta, \delta, \varepsilon, \sigma$ and ω while λs $\left(\lambda_{CO2}, \lambda_{ENC}, \lambda_{GDP}, \lambda_{GDP^2}, \lambda_{TR}\right)$ explore the long run associations between variables of interest. The hypothesis of no cointegration i.e. $\lambda_{CO2} = \lambda_{ENC} = \lambda_{GDP} = \lambda_{GDP^2} = \lambda_{TR} = 0$ is examined. The decision about cointegration is based on the computed F-statistic. The critical bounds to compare with the F-statistic have been tabulated by Pesaran et al. (2001)[7]. The upper critical bound (UCB) is based on the assumption that all variables are integrated at I(1) and the lower critical bounds (LCB) variables should be integrated at level. If UCB is lower than the F-statistic, then the decision is in favor of cointegration among the variables. It indicates the existence of long run relationship among the variables. If the F-statistic is less than LCB, then it favors no cointegration among the variables. The decision about cointegration will be inconclusive if the F-statistic falls between UCB and LCB. In such situation, we will have to rely on the finding of lagged error correction term (ECT) for cointegration to investigate the long run relationship. If there is long run relationship between variables, the short run behavior of variables is investigated by the following VECM model:

$$\Delta LCO2_t = \delta_0 + \sum_{j=0}^{n} \delta_1 \Delta LENC_t + \sum_{j=0}^{n} \delta_2 \Delta LGDP_t + \sum_{j=0}^{n} \delta_3 \Delta LGDP_t^2 + \sum_{j=0}^{n} \delta_4 \Delta LTR_t + \eta ECT_{t-1} + \varepsilon_t \qquad (4)$$

It is documented that if the value of lagged ECT is between 0 and -1, then adjustment to the dependent variable in current period is the ratio of error in the previous period. In such situation, ECT causes the dependent variable to converge to long span of time stable equilibrium due to variations in the independent variables. The goodness of fit for ARDL model is checked through stability tests such as cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ). Finally, sensitivity analysis is also conducted.

[7] We use Tuner's (2006) critical values instead of Pesaran et al. (2001) and Narayan (2005) because the lower and upper bounds by Turner (2006) are more suited for small sample data sets.

4. Empirical Results

The annual data on CO2 emissions and energy consumption are obtained from the World Development Indicators (WDI-CD-ROM, 2009). The Economic Survey of Pakistan (various issues) is used to comb the data for real GDP and trade openness. The sample period starts from 1971 to 2009.

The two step procedure of ARDL bound test requires lag length of variables. Based on the minimum value of Akaike Information Criteria (AIC), the optimum lag order is (1, 1, 1, 0, 1). The results are reported in Table 1. The F-statistic is greater than UCB infers that there is cointegration among the variables. The diagnostic tests show the validity of the estimation in the model.

Table 1: Bounds test for cointegration

Estimated equation	$CO_2 = f(ENC, GDP, GDP^2, TR)$	
F-statistics	10.0062***	
Optimum lag order	(1, 1, 1, 0, 1)	
Significant level	Critical values (T = 39)[#]	
	Lower bounds, $I(0)$	Upper bounds, $I(1)$
1 per cent	7.763	8.922
5 per cent	5.264	6.198
10 per cent	4.214	5.039
Diagnostic tests	Statistics	
R^2	0.8137	

Adjusted- R^2	0.6952
J-B Normality	0.9537 (0.6207)
Breusch-Godfrey LM	0.5885 (0.4515)
ARCH LM	0.0094 (0.9232)
Ramsey RESET	0.3780 (0.5452)

Note: The asterisks *** denote the significant at 1 per cent level.
Critical values bounds are computed by surface response procedure by Turner (2006).

The long run marginal impact of economic growth, energy consumption and trade openness on CO2 emissions is reported in Table 2. The results reveal that increase in energy consumption will increase CO2 emissions. It is documented that 1 percent rise in energy consumption raises CO2 emissions by 0.86 percent. The findings are in line with the literature such as Hamilton and Turton (2002), Friedl and Getzner (2003), Liu (2005), Ang and Liu (2005), Say and Yücel (2006), Ang (2008), Halicioglu (2009), Jalil and Mehmud (2009).

Table 2: Long run relationship

Dependent Variable = LCO2			
Variable	Coefficient	T-Statistic	Probability
Constant	-59.5359	-4.4192	0.0001
LENC	0.8644	4.6376	0.0001
LGDP	3.7483	3.9443	0.0004
$LGDP^2$	-0.0506	-3.0698	0.0044
LTR	-0.0855	-1.7927	0.0828

R-Squared = 0.9987
Adjusted R-Squared = 0.9985
Akaike info Criterion = -4.4858
Schwarz Criterion = -4.2659
F-Statistic = 6007.3990
Prob(F-Statistic) = 0.0000
Durbin-Watson = 1.9820
Sensitivity Analysis
Serial Correlation LM = 0.3033 (0.7406)
ARCH Test = 0.3210 (0.5747)
Normality Test = 2.0552(0.3578)
Heteroscedisticity Test = 0.4458 (0.8118)
Ramsey Reset Test = 1.9746 (0.1570)

Both linear and non-linear terms of real GDP confirm the existence of inverted-U relationship between economic growth and CO2 emissions. The results indicate that 1 percent rise in real GDP will rise CO2 emissions by 3.75 percent while negative sign of squared term seems to corroborate the delinking of CO2 emissions and real GDP at higher level of income in the country. This evidence confirms that CO2 emissions increase at initial stage of economic growth and decline after a threshold point. These findings are consistent with the empirical evidence of He (2008), Song et al. (2009), Halicioglu (2009), Fodha and Zaghdoud (2010) and Lean and Smyth (2010).

The coefficient of TR shows inverse impact on CO_2 emissions. It indicates that 0.09 percent of CO_2 emissions are declined with a 1 percent increase in international trade. Our finding supports the view by Antweiler et al. (2001), Copeland and Taylor (2005), McCarney and Adamowicz (2006) and Managi et al. (2008) that foreign trade reduces CO_2 emissions through technological effects in the country. However, this finding is contrary to Khalil and Inam (2006) who probed that international trade is harmful to environmental quality in Pakistan and Halicioglu (2009) who posited that foreign trade increases CO_2 emissions in Turkey.

The high value of R-squared and a battery of diagnostic tests confirm goodness fit of the estimated model and the stability of long run results. The unique order of integration leads a support to examine the direction of causality between economic growth and CO_2 emissions through Granger causality test. The same approach is applied for short run causality without the level feedback. The results reported in Table 3 indicate that real GDP (real GDP squared) Granger causes CO_2 emissions in long run as well as in short span of time at 5% level of significance. The causality result also confirms the existence of EKC in long run and short run (see for example, Coondoo and Dinda, 2002; Dinda and Coondoo, 2006; Akbostanci et al., 2009 and Lee and Lee, 2009). This empirical evidence is same with the finding of Maddison and Rehdanz (2008) for North America, Zhang and Cheng (2009) and Jalil and Mahmud (2009) for China and Ghosh (2010) for India.

Table 3: Granger causality test

Long Run Causality Results	F-Statistic	Prob. Value
LGDP does not Granger cause LCO2	4.0537	0.0160
LCO2 does not Granger cause LGDP	0.9634	0.4232
$LGDP^2$ does not Granger cause LCO2	3.8977	0.0186
LCO2 does not Granger cause $LGDP^2$	0.9183	0.4442
Short Run Causality Results		
DLGDP does not Granger cause DLCO2	4.9524	0.0136
DLCO2 does not Granger cause DLGDP	0.2798	0.7577
$DLGDP^2$ does not Granger cause DLCO2	4.3145	0.0222
DLCO2 does not Granger cause $DLGDP^2$	0.2811	0.7567

The short run dynamics results are reported in Table 4. Empirical evidence indicates that energy consumption leads to increase of CO2 emissions. It is noted that 1 percent rise in energy consumption will increase CO2 emissions by 0.6 percent. The sign of coefficients of GDP and GDP^2 are again according to our expectation and significant at 5% and 10% level of significance respectively. This validates the existence of inverted-U Kuznets curve in short run. It is noted that the long run income elasticities for CO2 emissions are less than the short run elasticities for CO2 emissions. This further proves the existence of EKC[8]. The short run effect of international trade is also negative but insignificant.

[8] For more details, please refer to Narayan and Narayan (2010).

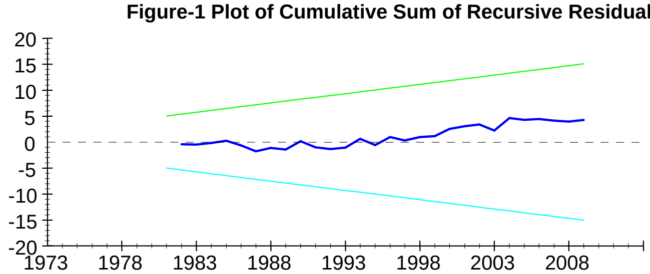
Table 4: Short run results

Dependent Variable = ΔLCO2			
Variable	Coefficient	T-Statistic	Probability
Constant	0.0303	7.3531	0.0000
ΔLENC	0.6077	2.2670	0.0308
ΔLGDP	11.3108	2.0736	0.0468
$\Delta LGDP^2$	-0.5283	-1.9280	0.0634
ΔLTR	-0.0582	-1.4275	0.1637
ecm_{t-1}	-0.1021	-6.1286	0.0000
R-Squared = 0.6605 Adjusted R-Squared = 0.6039 Akaike info Criterion = -4.4690 Schwarz Criterion = -4.2050 F-Statistic = 11.6730 Prob(F-statistic) = 0.0000 Durbin-Watson = 2.1142			
Sensitivity Analysis Serial Correlation LM = 0.8992 (0.4596) ARCH Test = 0.0216 (0.8839) Normality Test = 0.4129(0.8134) Heteroscedisticity Test = 0.6739 (0.7377) Ramsey Reset Test = 0.1405 (0.7104)			

The sign of coefficient of lagged ECM term is negative and significant at 1% level of significance. This corroborates the established long run relationship among the variables. Furthermore, the value of lagged ECM term entails that change in CO2 emissions from short run to long span of time is corrected by almost 10 percent over each year with high significance.

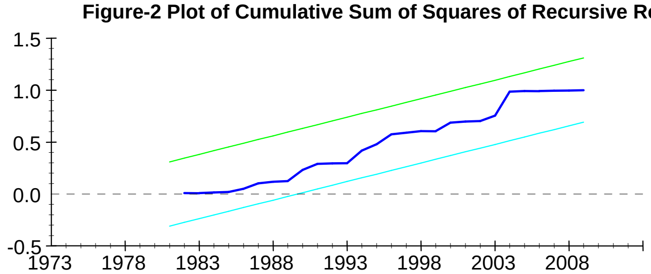
The diagnostic tests such as LM test for serial correlation, ARCH test, normality test of residual term, White heteroskedasticity and model specification test for short run model have also been conducted. The results are reported in Table 4. The empirical findings show that the short run model passes all diagnostic tests successfully. The evidence indicates no serial correlation, the residual term is normally distributed and the functional form of the model is well specified. There is no evidence of autoregressive conditional heteroskedasticity and White heteroskedasticity.

Figure-1 Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure-2 Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests have been employed to investigate the stability of long and short run parameters. Pesaran et al. (1999, 2001) suggested estimating the stability of long and short run estimate through CUSUM and CUSUMSQ tests. Figures 1 and 2 specify that plots for CUSUM and CUSUMSQ are between the critical boundaries at 5 % level of significance. This confirms the accuracy of long and short run parameters in the model.

5. Conclusion and policy implications

The aim of this paper is to investigate the relationship between CO2 emissions, energy consumption, economic growth and trade openness for Pakistan over the period of 1971-2009. The EKC hypothesis has been tested by applying ARDL model for cointegration. The result suggests that there exists long run relationship among the variables. The positive sign of linear and negative sign of non-linear GDP indicate that EKC hypothesis is supported in the country. The results of Granger causality tests show one-way causal relationship running from income to CO2 emissions. Energy consumption increases CO2 emissions both in short and long run. Openness to trade reduces CO2 emissions in long run but it is insignificant in short run.

The significant existence of EKC shows the country's effort to condense CO2 emissions. This indicates the reasonable achievement of controlling environmental degradation in Pakistan. However, this empirical evidence which is in aggregate data may not able to show the pattern of four provinces of Pakistan individually. The implementation of NEP itself is not enough. Effective enforcement of environmental laws and regulation is necessary not only at the federal level but also at the provincial level. Furthermore, research and development activities regarding environmental degradation which are important to attain sustainable development are still remaining unattainable in Pakistan. Therefore, to curb CO2 emissions, there is a need to implement environment taxes such as green tax.

Moreover, trade openness has beneficial effect on environmental quality in Pakistan. This supports the view by Antweiler et al. (2001) that international trade does not harm environment if the country uses cleaner technology for production after achieving a sustainable level of development. Our finding suggests that Pakistan must give her attention to import cleaner technology to develop her industrial sector. This not only enhances the production level but also becomes a safety valve against environmental degradation. The import of advance technology lowers environmental cost and develops the industrial sector. Keeping the composition effect constant, scale effect stimulates economic growth which raises production that increases industrial pollution. Industrial pollution can be reduced if government checks on scale effect by importing cleaner technology for industrial sector to attain maximum gains from international trade in the country.

The limitation of our study is the growth pattern of four provinces of Pakistan is different. For future, study can be focus on the provincial level to attain comprehensive impact of economic growth on CO2 emissions which will provide new insights for policy making authorities for controlling environmental degradation at provincial level.

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