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## **Financial Development, Energy Consumption and CO2 Emissions: Evidence from ARDL Approach for Pakistan**

### **Abstract:**

The paper explores the existence of a long run equilibrium relationship among CO2 emissions, financial development, economic growth, energy consumption, and population growth in Pakistan. ARDL bounds testing approach to cointegration is implemented to the data for 1974-2009. The results confirm a long run relation among these variables. Financial development appears to help reduce CO2 emissions. The main contributors to CO2 emissions however are: economic growth, population growth and energy consumption. Our results also lend support to the existence of Environmental Kuznets Curve for Pakistan. Based on the findings we argue that policy focus on financial development might be helpful in reducing environmental degradation.

**Key Words:** Financial Development, CO2 Emissions, Cointegration

**JEL Codes:** E44, O16

## I. Introduction

The Government of Pakistan launched the National Environmental Policy (NEP) to achieve sustained level of economic growth, and also to contain environmental degradation. The salient features of the NEP are to "protect, conserve and restore Pakistan's environment in order to improve the quality of life of the citizens through sustainable development" (GoP, 2009, p. 221). Sustainable economic development and sustainable environmental program are two sides of the same coin. Economic growth usually originates in the industrial sector led by big manufacturing<sup>1</sup> where energy use is high which tends to pollute the environment. In 2002-03, 36% and 33% of the energy consumption was accounted for by manufacturing and transportation sectors, respectively. By 2008-09 total energy consumption declined to 29%, but industrial use rose to 43%<sup>2</sup>.

Dependence on hydrocarbon as the major source of energy is the main reason of CO<sub>2</sub> emissions<sup>3</sup>. Natural gas, used in producing electricity, is a major contributor to CO<sub>2</sub> emission. Coal alone accounts for over 50% of all CO<sub>2</sub> emissions. In 2005, Pakistan's share to global CO<sub>2</sub> emissions was 0.4%. This situation will worsen further as the economic prosperity of Pakistan continues. The nation has seen its per capita income rise from PRs 32,599<sup>4</sup> to PRs 36,305 between 2006 and 2009 (11.4%). During the same period per capita energy consumption rose from 489.36 to 522.66 in kg of oil equivalent per capita (6.8%); but over the same period CO<sub>2</sub> emissions rose from 0.7657 to 1.02597 (metric tons) i.e. 34% per capita.

Alam et al. (2007) applied Johansen multivariate cointegration approach examine long run impact of growth in population, income per capita, energy intensity and urbanization on environmental degradation in Pakistan. They found that a 1% increase in per capita GDP growth

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<sup>1</sup> In 2009, economic growth rate was a meager 2.0% due to poor performance of manufacturing sectors (Economic Survey of Pakistan, 2008-2009).

<sup>2</sup> Economic Survey of Pakistan, 2008-2009, p. 226.

<sup>3</sup> The nature of transportation has been converting to compressed gas consumption after hike in petroleum prices in the country.

<sup>4</sup> 1 US\$ = PRs 83 (Pakistan Rupees)

rate leads to 0.84% increase in the growth rate of CO<sub>2</sub>; and 1% increase in the energy intensity growth rate causes almost 0.24% increases in the growth rate of CO<sub>2</sub> emissions. Although contemporary research shows that financial development has favorable impact on CO<sub>2</sub> emissions, Alam did not consider this factor. In addition, the inclusion of both population and urbanization as explanatory variables can potentially cause multicollinearity. Our study contributes to the energy literature in two distinct ways. First, we extend the work of Alam et al. (2007) by including financial development. (ii) Second, we implement the ARDL bounds testing approach to cointegration to examine long run equilibrium relationship among CO<sub>2</sub> emissions, financial development, economic growth, energy consumption, and population growth for Pakistan. The ARDL approach is better suited in the case of small samples.

Financial development can promote economic growth and reduce environmental pollution. As Frankel and Romer (1999) point out, developed financial market can help inflow of foreign direct investment and stimulate the rate of economic growth of the receiving nations. Financial development serves as a conduit for modern environment-friendly technology (Birdsall and Wheeler, 1993; Frankel and Rose, 2002). Recent studies show that financial development has direct impact on energy consumption (e.g., Sadorsky, 2010) and thus on CO<sub>2</sub> emissions (Tamazian et al. 2009). A developed financial sector lowers borrowing cost, promotes investment in energy efficient sector, and reduces energy emissions (Tamazian et al. 2009; Tamazian and Rao, 2010; Sadorsky, 2010; Shahbaz, 2009a; Shahbaz et al. 2010b). Specifically, the national, regional and local governments can take advantage of lower borrow cost to fund environment friendly projects. Jensen (1996) on the other hand found that financial development increases CO<sub>2</sub> emission through industrial growth enhancing-affect.

The foregoing discussion shows a lack of consensus on the effect of the financial development on CO<sub>2</sub> emission. This may be due to country specific conditions which need to be considered and analyzed. It is against this back drop that the present study is undertaken to better understand the relationship in the context of Pakistan. The theoretical and empirical literature tends to support the idea that the inclusion of financial development might make significant difference in outcome when examining its role in economic growth and environmental degradation. From that perspective, the present study concerning Pakistan economy is well justified.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 describes data sources and the empirical methodology. Results are reported in Section 4, conclusions and policy prescriptions are offered in the final section.

## **II. Review of Relevant Literature**

The relation among CO<sub>2</sub> emissions, energy consumption and economic growth has intrigued both the academicians and the policymakers. For instance, Manne and Richels, (1992); Grove, (1992); Anderson, (1992); Jorgenson and Wilcoxon, (1993); Kolstad and Krautkraemer, (1993); Xepapadeas, (2005) and others found positive relation relationship between sustainable economic development and energy emissions. Selden and Song (1994), Shafik (1994), Antle and Heidebrink (1995), Grossman and Krueger (1995) argue that the adverse effect on environment is not inevitable. In fact, some particular policy regimes can help redress many of the problems.

The impact of economic growth on environment depends on the type of energy emissions. For instance, sulfur dioxide, carbon monoxide and nitrogen oxide have detrimental effects on health and environment. This relationship between air pollution and economic development also appears in an inverted-U shaped or monotonically decreasing form [Shafik and Bandyopadhyay, 1992; Hettige et al., 1992; Diwan and Shafik, 1992]. Selden and Song (1994) confirmed

environmental Kuznets hypothesis after investigating the relationship between economic growth and a set of energy pollutants i.e. SO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>. Using unbalanced data from 130 countries to examine the relationship between real income per capita and CO<sub>2</sub> emissions, Holtz-Eakin and Selden (1995) reported positive link between the two, but did not find EKC. Dinda et al (2000) used data from 33 countries classified as low, middle, and high income; to examine the relationship between economic growth and CO<sub>2</sub> emissions. They found that the use of advanced capital-intensive techniques help environment and supports EKC relation. Persson et al. (2006) notes that the cost to improve environment will be less if developing nations implement environment friendly policies at the initial stages of economic development.

Ang (2007) applied ARDL bounds testing approach to cointegration to France and found stable long run relation between economic growth and CO<sub>2</sub> emission. He found causality runs from economic growth to energy consumption and CO<sub>2</sub> emissions in the long run; but in the short run energy consumption causes economic growth. In his study on Malaysia, Ang (2008) found positive link between GDP per capita, energy consumption, CO<sub>2</sub> emissions. Causality runs from output to energy consumption not only in the short, but also in the long run. Halicioglu (2009) examine the relationship between income per capita, carbon emissions, energy use and trade openness for Turkey. Results from ARDL bounds testing approach support cointegration among the series. In addition to EKC relation, he also found that energy consumption, trade and CO<sub>2</sub> emissions are the main contributors to economic growth in the long run. Bhattacharyya and Ghoshal, (2009) explore the relationship among CO<sub>2</sub> emissions, population and per capita GNP using data from 25 countries. They found causality runs from energy consumption to CO<sub>2</sub> emissions for most countries; also higher population growth adds to higher CO<sub>2</sub> emissions. Lean and Smyth (2009, 2010) examined the relation between electricity consumption, CO<sub>2</sub> emissions and output for

ASEAN countries using a panel vector error correction model. They found a positive and significant long run relation between electricity consumption and CO<sub>2</sub> emissions. The CO<sub>2</sub> emissions and GDP per capita relation supports the existence of EKC<sup>5</sup>. Apergis and Payne (2009) extended the work by Ang (2007) to examine the causality between CO<sub>2</sub> emissions, energy consumption, and output in Central American countries. In addition to support for the EKC hypothesis, they also found unidirectional causality running from energy consumption and real output to CO<sub>2</sub> emissions. Finally, Shahbaz et al. (2010c) found the existence of EKC for Pakistan.

Müller-Fürstenberger and Wagner (2007) and Stern (2004) discuss theoretical and econometric issues of EKC. Song et al. (2008) used panel cointegration to Chinese provincial level data and found long run relationship between economic growth and indicators of CO<sub>2</sub> emissions i.e. waste gas, waste water, solid wastes etc., which confirms an inverted U relationship. Using panel and cross-section data, Wagner (2008) also found an inverted U-relation between economic growth and energy pollutants i.e. CO<sub>2</sub> and SO<sub>2</sub>. Akbostanci et al. (2009) examined Turkish data but did not find support for the EKC. Esmaili et al. (2009) investigate EKC relation using oil exploitation factors e.g., oil reserves, oil price, population, political rights, and the Gini index in the oil producing countries and found support for the EKC. Finally, Fodha et al. (2010) examine the relationship between energy emissions (CO<sub>2</sub> and SO<sub>2</sub>) and GDP per capita for Tunisia. They find evidence in supports an EKC between economic growth and SO<sub>2</sub> emissions, and but not with regard to CO<sub>2</sub> emissions.

Although research has mainly focused on the relationship between economic growth and indicators of energy emissions e.g., CO<sub>2</sub>, SO<sub>2</sub>, PM<sub>10</sub> and NO<sub>x</sub>, not much attention has been paid to the role of financial development in reducing CO<sub>2</sub> emissions. Claessens and Feijen (2007) posit that good governance and financial development can improve environmental quality. Financial

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<sup>5</sup> Ghosh (2010) finds only short run, no long run causality between economic growth and CO<sub>2</sub> emissions in India.



development makes it easier to adopt advanced technology in energy sector which helps reduce CO<sub>2</sub> emissions significantly (Kumbaroglu et al., 2008). The authors suggest that investment in technology improves the efficiency of energy sector. Tadesse (2005) finds that financial development encourages technological progress -- a major determinant of productivity. Financial development stimulates investment by risk sharing (Shahbaz et al. 2010b). Lanoie et al., (1998) note that financial market can help reduce CO<sub>2</sub> emissions by providing incentives to firms for compliance of environmental regulations. Dasgupta et al. (2004) find that firms in Korea lose market value if their names are made public for violation of environmental regulations.

Recently, Tamazian et al. (2009) examined the impact of economic and financial development on CO<sub>2</sub> emissions for BRIC nations plus the United States and Japan. They found that both the factors help reduce CO<sub>2</sub> emissions. The authors also found that trade liberalization and financial sector reforms help reduce CO<sub>2</sub> emissions. Tamazian and Rao (2010) applied GMM approach to find the effect of institutional, economic and financial development on CO<sub>2</sub> emissions for the transitional economies. They found that these factors help lower CO<sub>2</sub> emissions. They also found support in favor of EKC. Using provincial data from China, Yuxiang and Chen (2010) found that financial development reduces industrial pollutants. They claim that financial development induces capitalization, technology, income and regulations that effects environmental quality. Jalil and Feridun (2010) investigate the impact of financial development, economic growth and energy consumption on environmental pollution in China using aggregate data over the period of 1953-2006. Their results indicate that financial development lowers CO<sub>2</sub> emissions. The results suggest that financial development in China has helped improve environment. On contrarily, financial development and CO<sub>2</sub>emissions nexus is also reinvestigated by Zhang (2011) for case of Chinese economy and compared the findings by using vector error correction method (VECM) and variance

decomposition approach. The empirical evidence reveals that financial development significantly contributes to increase in environmental degradation. Zhang pointed out that Chinese enterprises have easy access to external finance by providing bank loans at cheaper cost to enhance investment scale. This leads China's economic growth and CO2 emissions to intensify which depends on bank asset scale expansion. The effect of stock market scale and stock market efficiency is relatively larger and weaker on environmental degradation is due to Chinese's stock markets characteristics<sup>6</sup>.

### III. Data, econometric model and estimation techniques

The data on CO2 emissions (measured in kt); financial development, proxied by real market capitalization (MC); growth in real GDP per capita (GDP) for economic growth; energy consumption (ENC) and population (POP) as size of an economy; has been taken from world development indicators (WDI-CD-ROM, 2010).

This study explores a long run relation among financial development, growth in income, energy consumption, population and CO2 emissions in Pakistan. Following Talukdar and Meisner (2001), Temazian et al. (2009) and Jalil and Feridun (2010), we use a multivariate framework using data from 1974-2009 for Pakistan. All the series have been converted into natural logarithm. The equation to be estimated is specified as below:

$$CO_2 = f(FD, ENC, GDP, POP) \quad (1)$$

$$\ln CO_2 = \beta_1 + \beta_{FD} \ln FD + \beta_{ENC} \ln ENC + \beta_{GDP} \ln GDP + \beta_{POP} \ln POP + \mu_t \quad (2)$$

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<sup>6</sup> For instance, A compared with developed countries, the history of China's stock markets is pretty shorter, hence the related market mechanism design is not complete and standardized; China's stock market trading behavior and price are affected not only by the economic factor but also by some other factors, such as domestic political situation, stock market participators' psychology and illegal activities; and some times the influence of the latter even outweighs that of the former; governmental actions about stock market operations often appear irrational, which makes related policies lack consistency, succession and transparency; external finance of some listed enterprises is not fully used for productive projects or even the assigned projects.

where, the variables are as defined earlier, and  $\mu_t$  is a residual term, assumed to be normally distributed. To check for an Environmental Kuznets curve relation, we add a squared term of GDP per capita along with financial development in the model. The equation is being estimated is:

$$\ln CO_2 = \alpha_1 + \alpha_{FD} \ln FD + \alpha_{ENC} \ln ENC + \alpha_{GDP} \ln GDP + \alpha_{GDP^2} \ln GDP^2 + \alpha_{POP} \ln POP + \mu_t \dots (3)$$

A priori, financial development reduces CO2 emissions thus we expect  $\beta_{FD} < 0$ . Economic activity is stimulated by increased energy consumption which in turn increases CO2 emissions. So we expect  $\beta_{ENC} > 0$ . The EKC hypothesis to hold, we expect  $\alpha_{GDP} > 0$  and  $\alpha_{GDP^2} < 0$ . The higher is the growth rate of population, the more is the demands energy and thus energy emissions. We expect the sign of population,  $\beta_{POP} > 0$ .

To establish long run relation among the series we implement ARDL bounds testing approach to cointegration *a la* Pesaran et al., (2001). The bounds testing approach has several advantages. The method applies irrespective of the order of integration, I(0) or I(1); is better suited to small samples; and a dynamic error correction model (ECM) can be derived from the ARDL model through a simple linear transformation. The ECM integrates the short-run dynamics with the long-run equilibrium without losing long-run information. The unrestricted version of error correction model of ARDL approach is given below following equation-4:

$$\Delta \ln CO_2 = \alpha_0 + \alpha_1 T + \sum_{i=1}^p \beta_i \Delta \ln CO_2_{t-i} + \sum_{i=1}^q \delta_i \Delta \ln FD_{t-i} + \sum_{i=1}^r \varepsilon_i \Delta \ln GDP_{t-i} + \sum_{i=1}^t \sigma_i \Delta \ln ENC_{t-i} + \sum_{i=1}^u \phi_i \Delta \ln POP_{t-i} \dots (4)$$

$$+ \lambda_{CO_2} \ln CO_2_{t-1} + \lambda_{FD} \ln FD_{t-1} + \lambda_{GDP} \ln GDP_{t-1} + \lambda_{MC} \ln ENC_{t-1} + \lambda_{POP} \ln POP_{t-1} + \mu_t$$

In equation-4,  $\beta, \delta, \varepsilon, \sigma$  and  $\phi$  refer to the short run, and  $\lambda_{CO_2}, \lambda_{FD}, \lambda_{GDP}, \lambda_{ENC}, \lambda_{POP}$  to the long parameters. The null hypothesis of no cointegration is  $\lambda_{CO_2} = \lambda_{FD} = \lambda_{GDP} = \lambda_{ENC} = \lambda_{POP} = 0$ . The rejection of the null i.e.  $\lambda_{CO_2} \neq \lambda_{FD} \neq \lambda_{GDP} \neq \lambda_{ENC} \neq \lambda_{POP} \neq 0$ , based on the F-statistic suggests cointegrating relation. The critical bounds have been tabulated by Pesaran et al. (2001). The upper critical bound (UCB) is based on the assumption that all series are I(1). The lower bounds (LCB) applies if the series are I(0). If UCB is lower than the calculated *F-statistic*, the claim of cointegration is sustained. If the *F-statistic* is less than the LCB then there is no cointegration. The decision about cointegration will be inconclusive if the *F-statistic* lies between UCB and LCB. In such situation, we will have to rely on the lagged error correction term to investigate long run relationship. If a long run relationship exists, short run behavior is investigated using ECM version of ARDL model in equation-5.

$$\Delta \ln CO_2 = \delta_0 + \sum_{i=0}^m \delta_1 \Delta \ln FD + \sum_{j=0}^n \delta_2 \Delta \ln ENC + \sum_{k=0}^o \delta_2 \Delta \ln GDP + \sum_{l=0}^p \delta_3 \Delta \ln POP + \eta ECM_{t-1} + \varepsilon_t \quad (5)$$

The lagged residual term in equation-5 shows the changes in dependant variable. These changes are not only due to the levels of disequilibrium in the cointegration, but also in the other explanatory variables which points to the convergence of the dependant variable from short to long run equilibrium relationship (Masih and Masih, 1997). In such situation, the error correction term (ECM) causes the dependent variable to converge to the long run stable equilibrium. The  $\delta_0$  is constant term. 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). Sensitivity analysis is checks problems associated with the short run model.

#### IV. Empirical Results

The descriptive statistics and correlation matrix are presented in Table-1. Financial development and energy emissions are positively correlated, but insignificant. Population is negatively related to energy emissions and financial development, but insignificant. Energy emission is positively linked with economic growth and energy demand, and significant. Economic growth and financial development; and energy demand and financial development; are positively related, but insignificant. In terms of the Jarque-Bera test, all the series follow normal distribution.

**Table-1: Descriptive Statistics and Correlation Matrix**

| Variables   | $\ln CO2_t$ | $\ln FD_t$ | $\ln GDP_t$ | $\ln POP_t$ | $\ln ENC_t$ |
|-------------|-------------|------------|-------------|-------------|-------------|
| Mean        | 11.0713     | 7.5970     | 28.5798     | 18.5239     | 5.9781      |
| Median      | 11.1607     | 7.6207     | 28.6723     | 18.5353     | 6.0206      |
| Maximum     | 12.0035     | 10.3576    | 29.4474     | 18.9462     | 6.2724      |
| Minimum     | 9.96743     | 5.5715     | 27.6310     | 18.0469     | 5.6566      |
| Std. Dev.   | 0.6229      | 1.4883     | 0.5318      | 0.2694      | 0.1976      |
| Skewness    | -0.3098     | 0.2813     | -0.2339     | -0.1167     | -0.3166     |
| Kurtosis    | 1.8668      | 1.9321     | 1.9478      | 1.8310      | 1.7233      |
| Jarque-Bera | 2.5019      | 2.1854     | 1.9891      | 2.1315      | 3.0464      |
| Probability | 0.2862      | 0.3353     | 0.3698      | 0.3444      | 0.2180      |
| $\ln CO2_t$ | 1.0000      |            |             |             |             |
| $\ln FD_t$  | -0.1086     | 1.0000     |             |             |             |
| $\ln GDP_t$ | 0.4439      | 0.2369     | 1.000000    |             |             |
| $\ln POP_t$ | 0.1783      | -0.1873    | 0.165971    | 1.000000    |             |
| $\ln ENC_t$ | 0.5549      | 0.2460     | 0.410207    | -0.046331   | 1.000000    |

Pesaran et al. (2001) critical values are based on the assumption that the variables are stationary of order  $I(0)$  or  $I(1)$ . Ouattara (2004) noted that in the presence of  $I(2)$  series the computed F-statistics may be misleading. Unit root tests insure that none of the series is integrated of  $I(2)$  or higher. The Augmented Dickey-Fuller (ADF), unit root tests has been employed to for testing unit root. The results suggest that financial development, economic growth, energy consumption, population and CO2 emissions have unit root problem at level but stationary at their 1<sup>st</sup> differenced form i.e.

integrated at I(1) [Table-2]. After confirming the order of integration, we estimate the UECM cointegration to select the optimal lag length<sup>7</sup> using the Akaike's Information Criterion (AIC).

**Table-2: Unit Root Estimation**

| ADF Test at Level with Intercept and Trend                      |              |             |
|---|--------------|-------------|
| Variable  | T-Statistics | Prob-Value* |
| $\ln CO2_t$   | -0.9188      | 0.9430      |
| $\ln FD_t$  | -2.1697      | 0.4904      |
| $\ln GDP_t$   | -1.3427      | 0.8610      |
| $\ln ENC_t$   | -1.4267      | 0.8361      |
| $\ln POP_t$   | -1.2582      | 0.8827      |
| ADF Test at 1 <sup>st</sup> Difference with Intercept and Trend |              |             |
| $\Delta \ln CO2_t$  | -5.6502      | 0.0002      |
| $\Delta \ln FD_t$   | -3.7192      | 0.0350      |
| $\Delta \ln GDP_t$  | -5.5923      | 0.0003      |
| $\Delta \ln ENC_t$  | -3.9082      | 0.0219      |
| $\Delta \ln POP_t$  | -3.5376      | 0.0350      |

Note: \*MacKinnon (1996) one-sided p-values.

Narayan (2005) argue that the critical values from Pesaran et al. (2001) are inappropriate for small sample. Given that the small sample ( $T = 39$ ), we apply the critical values from the surface response procedure developed by Turner (2006). The UECM cointegration results show that the calculated F-statistics exceeds the critical values at the 5 per cent level when financial development, CO2 emissions, energy consumption and population are forcing variables. Our calculated F-statistics is 7.4441 while upper critical bound is 6.198. This implies that there is long run relationship between financial development, economic growth, energy consumption, population and CO2 emissions over the period of 1974-2008 in case of Pakistan.

<sup>7</sup> For more details see Shahbaz (2009a) and Shahbaz et al. (2010a)

**Table-3: The Results of Cointegration Test**

| Model for Estimation                  |                                 |                                 | F-Statistics       |        | Lag      |
|---------------------------------------|---------------------------------|---------------------------------|--------------------|--------|----------|
| $(CO2_t / FD_t, GDP_t, ENC_t, POP_t)$ |                                 |                                 | 1.5738             |        | 2        |
| $(FD_t / CO2_t, GDP_t, ENC_t, POP_t)$ |                                 |                                 | 4.6214             |        | 2        |
| $(GDP_t / FD_t, CO2_t, ENC_t, POP_t)$ |                                 |                                 | 3.2307             |        | 2        |
| $(ENC_t / FD_t, CO2_t, GDP_t, POP_t)$ |                                 |                                 | 7.4441*            |        | 2        |
| $(POP_t / FD_t, CO2_t, GDP_t, ENC_t)$ |                                 |                                 | 2.7143             |        | 2        |
| Diagnostic Tests                      |                                 |                                 | Significance Level | LCB    | UCB      |
|                                       |                                 |                                 | 1%                 | 7.763  | 8.922    |
|                                       |                                 |                                 | %5                 | 5.264  | 6.198    |
|                                       |                                 |                                 | 10%                | 4.214  | 5.039    |
| Model for Estimation                  | LM                              | RESET                           | Normality          | CUSUM  | CUSUMsq  |
| $(CO2_t / FD_t, GDP_t, ENC_t, POP_t)$ | 0.3322<br>[0.5734]              | 1.3728<br>[0.2877]              | 1.6312<br>[0.4423] | Stable | Stable   |
| $(FD_t / CO2_t, GDP_t, ENC_t, POP_t)$ | 0.1784<br>[0.8371]              | 1.2780<br>[0.2641]              | 0.1486<br>[0.9283] | Stable | Stable   |
| $(GDP_t / FD_t, CO2_t, ENC_t, POP_t)$ | 3.2384 <sup>a</sup><br>[0.0903] | 0.0174<br>[0.8969]              | 0.5076<br>[0.7758] | Stable | Stable   |
| $(ENC_t / FD_t, CO2_t, GDP_t, POP_t)$ | 1.1625<br>[0.3421]              | 0.1547<br>[0.6999]              | 0.2421<br>[0.8859] | Stable | Stable   |
| $(POP_t / FD_t, CO2_t, GDP_t, ENC_t)$ | 1.3620<br>[0.3320]              | 9.5088 <sup>a</sup><br>[0.0115] | 3.6924<br>[0.1578] | Stable | Unstable |

Note: The asterisks \* denote the significance at 5 per cent level. The optimal lag structure is determined by AIC. The probability values are given in parenthesis. # Critical values bounds computed by surface response procedure.

The elasticity of CO2 emission with respect to economic growth, financial development, energy consumption and population is reported in Table-4. The coefficient shows that a 1 percent rise in economic growth is expected to increase CO2 emissions by 0.62 percent, all else same while Alam et al. (2007) reported that 1 per cent increase in economic growth is linked with 0.84 per cent increase in CO2 emissions. These findings are consistent with those of He (2008) for China; Song et al. (2008) for China; Halicioglu, (2009) for Turkey; Jalil and Mehmud, (2009) for China; Fodha

and Zaghoud, (2010) for Tunisia; Lean and Smyth, (2010) for ASEAN countries and Shahbaz et al. (2010c) for Pakistan.

**Table-4: Long Run Relationship**

| Dependent Variable = $\ln CO2_t$ |             |                 |             |                  |
|----------------------------------|-------------|-----------------|-------------|------------------|
| Variable                         | Coefficient | Prob-Value      | Coefficient | Prob-Value       |
| Constant                         | -20.6928    | 0.0000          | -77.4156    | 0.0008           |
| $\ln GDP_t$                      | 0.6202      | 0.0001          | 4.43928     | 0.0035           |
| $\ln GDP_t^2$                    | ....        | ....            | -0.06957    | 0.0098           |
| $\ln FD_t$                       | -0.0317     | 0.0013          | -0.0036     | 0.8003           |
| $\ln ENC_t$                      | 1.1873      | 0.0000          | 0.9893      | 0.0000           |
| $\ln POP_t$                      | 0.3876      | 0.0392          | 0.6786      | 0.0031           |
| Diagnostic tests                 |             | Statistics      |             | Statistics       |
| Durbin-Watson                    |             | 1.94144         |             | 2.34910          |
| J-B Normality test               |             | 1.3503 (0.5090) |             | 1.0360 (0.5957)* |
| Breusch-Godfrey LM test          |             | 0.0452 (0.9558) |             | 0.5698 (0.4922)  |
| ARCH test                        |             | 0.0452 (0.9558) |             | 0.4756 (0.4609)  |
| Heteroscedisticity Test          |             | 0.9835 (0.4628) |             | 0.7911 (0.7269)  |
| Ramsey RESET                     |             | 2.9440 (0.0501) |             | 0.0300 (0.9703)  |
| CUSUM                            |             | Stable (5%)     |             | Stable (5%)      |
| CUSUM of Square                  |             | Stable (5%)     |             | Stable (5%)      |

\*P- values for the diagnostic tests are in parenthesis

The impact of financial development on energy emissions is negative and it is significant at the 1 percent level. This suggests that development of financial improves environment. The results indicate that 1 percent increase in financial development reduces energy emissions by 0.0317 percent, on average all else same. This happens because financial sector development comes with financial reforms which attract FDI. The latter boosts R&D, promotes investment and stimulates economic growth. Superior foreign technology improves environmental quality. The findings are consistent with those found by Birdsall and Wheeler (1993), Frankel and Romer (1999), Frankel and Rose (2002) and Tamazian et al (2009, 2010). As for the relationship between energy consumption and energy emissions in Pakistan, the results suggest that a 1% increase in energy consumption leads to an expected increase in energy emissions by 1.187 percent, ceteris paribus.



The findings are in line with Hamilton and Turton (2002), Friedl and Getzner (2003), Liu (2005), Ang and Liu (2005), Say and Yücel (2006), Ang (2008) and others. The rise in population is positively associated with energy emissions. A 1 percent increase in population leads to 0.38 percent increase energy emissions, all else same.

As for the of EKC relation, the coefficients of both linear and non-linear terms of GDP per capita lend support to an inverted-U relationship between economic growth and energy emissions in the long run. The coefficients of linear and non-linear terms are 4.439 and (-0.0695) respectively. Both of these coefficients are highly significant for Pakistan as shown in Table-4 and consistent with the findings of Shahbaz et al. (2010c).

**Table-5: Short Run Results**

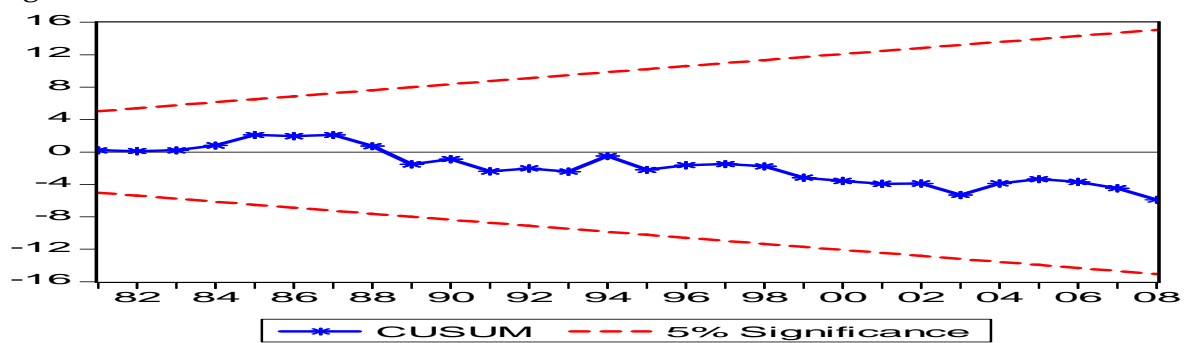
| Dependent Variable = $\Delta \ln CO_2$  |             |            |             |            |
|---|-------------|------------|-------------|------------|
| Variable  | Coefficient | Std. Error | T-Statistic | Prob-Value |
| Constant  | 0.0123      | 0.0401     | 0.3069      | 0.7611     |
| $\Delta \ln GDP_t$  | 0.6801      | 0.2381     | 2.8563      | 0.0080     |
| $\Delta \ln FD_t$   | -0.0263     | 0.0147     | -1.7826     | 0.0855     |
| $\Delta \ln ENC_t$  | 0.9732      | 0.2825     | 3.4438      | 0.0018     |
| $\Delta \ln POP_t$  | -0.0437     | 1.5822     | -0.0276     | 0.9782     |
| $ECM_{t-1}$   | -0.1066     | 0.0204     | -5.2146     | 0.0000     |
| R-Squared = 0.69113<br>Adjusted R-Squared = 0.63597<br>S.E. of Regression = 0.02368<br>Akaike info Criterion = -4.48882<br>Schwarz Criterion = -4.21947<br>F-Statistic = 12.53075<br>Prob(F-statistic) = 0.0000<br>Durbin-Watson = 1.8780 |             |            |             |            |
| <u><b>Sensitivity Analysis</b></u><br>Serial Correlation LM = 0.6418 (0.5343)<br>ARCH Test = 0.0018 (0.9657)<br>Normality Test = 1.0162(0.60164)<br>Heteroscedisticity Test = 0.5332 (0.8488)<br>Ramsey RESET Test = 2.2188 (0.1479)      |             |            |             |            |

The results of error correction model, reported in Table-5, reveal that economic growth is linked positively with energy emissions. We find 0.68 percent rise in energy emissions from a 1 percent increase in economic growth, on average, *ceteris paribus*, but the long run results are more reassuring. A 1 percent increase in financial development causes 0.026 percent reduction in energy emissions. The results suggest that the average energy emissions rise by 0.97 percent from a 1 percent increase in energy use. The impact of population on energy emissions is negative but insignificant. The sign of coefficient of lagged ECM term is negative and significant at the 1% level. This establishes long run relation among the running variables. The value of lagged ECM term, -0.1066 suggests that changes in energy emissions from short run to long span of time is corrected by 10.66 percent each year in Pakistan.

### Sensitivity Analysis and Stability Test

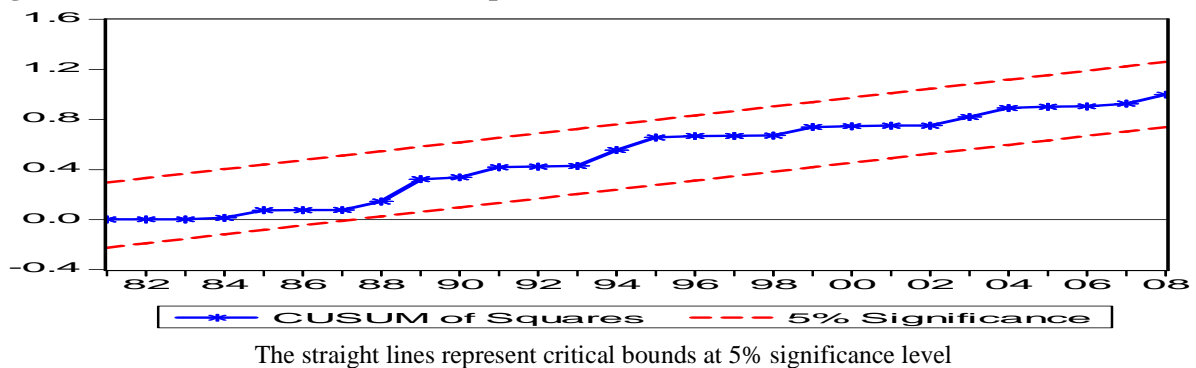
The diagnostic tests e.g., LM for serial correlation, normality of residual terms, white heteroskedasticity and specification for the short run model are reported in Table-5. The results suggest that the short-run model passes all diagnostic tests. We find no evidence of serial correlation, autoregressive conditional heteroskedasticity and white heteroskedasticity. The residual terms are normally distributed and the functional form of the model appears well specified.

**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**



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. (2000, 2001) suggest that the stability of long and the short run estimate be verified using the CUSUM and CUSUMSQ tests. Figures 1 and 2 provide the plots for CUSUM and CUSUMsq. These are between the critical bounds at the 5 % level, thus are stable.

## V. Conclusions and Policy Implications

The present article investigates a long run relation among financial development, economic growth, energy consumption, population and energy emissions for Pakistan using data for the period 1974 to 2009. The ARDL bounds testing approach to cointegration has been implemented for establishing the long run and the ECM for short run dynamics. Stationarity of the series has been examined by the ADF unit root test. All series are difference stationary.

Economic growth in Pakistan has been accompanied by use of coal, oil and natural gas, all contributors to higher CO<sub>2</sub> emissions. The policy shift towards financial development is expected to profoundly impact economic growth and CO<sub>2</sub> emission. If financial development indeed leads to energy efficiency, Alam et al (2007) might have overestimated the true impact on CO<sub>2</sub> emission. Our short run and long run impacts are smaller, and appear reassuring compared to Alam.

Our findings suggest that financial development reduces energy emissions both in the long and the short run. Economic growth adds to energy emissions. Our estimates show a better results compared to that of Alam (2007). This is due to the inclusion of the financial development variable which seems appropriate for Pakistan. We also find support for the existence of an inverted-U relationship – an EKC for Pakistan. Energy consumption is the main contributor to CO<sub>2</sub> emissions both in the long run and the short run; and population growth adds to emissions.

Our results suggest that financial development can play significant role in improving the quality of environment. The policy emphasis on financial development is a testimony to that outcome. The government should establish a comprehensive policy to support and monitor its implementation. Such action can help inflow of FDI, encourage transfer of advanced technology and enhance production; and at the same time make the economy less carbon-dependent.

Policy should however encourage preservation of natural resources for sustained economic growth which will produce better welfare outcomes. We tend to agree with Alam (2007) on priority to land-use and land conversions as part of national policy. Investments to exploit underutilized energy resources and to improve generation, distribution and consumption will help. However the long term strategy should emphasize conservation as search for alternative sources of energy is pursued. One area that will need major emphasis is how to meet the growing needs of a fast growing population and at the same time address resource use that includes environmental protection. Of importance are issues as they relate to sustainable use of renewable and non renewable resources such as land, water, fisheries and forests etc. Strengthening and enforcing of regulations governing pollution taking cognizance of the challenges posed by achievement of efficiency and sustainability will be necessary.

In the recent decades emphasis on food security has added pressure on agriculture and intensive land use which has been further aggravated by unplanned urbanization and rapid industrial growth. They have led to deforestation, land degradation, pressure on surface and underground water, pollution from energy generation. The primary causality of energy extraction, processing and use is the environmental quality and the ecology due to side effect of pollution.

Pakistan has sizeable natural gas which is more environment-friendly which makes this an obvious choice over coal use. Technological innovation can help reduce the emissions of pollutants. The nexus between energy use and economic growth there can work through several pathways each with differential impact on environment and there are limits to substitution opportunities. One area that needs careful examination is how to create policy incentive that will reduce energy consumption through lifestyle and lead to use of energy-conserving devices.

Arguably the amount of CO<sub>2</sub> emission depends on the size of its economy, and other factors e.g., the level of industrialization, urbanization and the efficiency of energy use. Financial development can be a key to achieving them as the paper has shown. There is little doubt as to recognizing the fact that the risk of global warming lies in the actions taken not only by the developed but also the emerging countries. It is a global issue and must be addressed globally.

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