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IMPACT OF FOSSIL FUEL ENERGY CONSUMPTION ON CO_2 EMISSIONS: EVIDENCE FROM PAKISTAN (1980-2010): A REVISIT

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Abstract

The present study empirically analyzes the impact of fossil fuel energy consumption on CO_2 emission for Pakistan using data from 1980-2010. Our broad objective is to test the environmental Kuznets curve (EKC) hypothesis and factors that affect the energy consumption. We have used Johansen Cointegration approach and a Vector Error Correction Model (VECM) to test the long run as well as short run relationship between variables. A log linear quadratic equation is specified to test the EKC hypothesis. Results support the existence of inverted U hypothesis. Industrial value added and trade openness positively affect the CO_2 emission while financial development reduces the CO_2 emission. Results of the energy consumption equation show that income, investment, population and manufacture export positively affect the energy consumption while manufacture import negatively affect the energy consumption.

Keywords: CO_2 Emission, Fossil fuel energy consumption, GDP per capita, Environmental Kuznets Curve(EKC),Unit Root Testing, Maximum Likelihood Cointegration Approach, Vector Error Correction Model.

1. Introduction

Global environmental issues are getting more attention especially the increasing threat of global warming and climate change. Higher global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level are some evidence of warming of the climate system. The intergovernmental panel on climate change (IPCC) reported a 1.1 to 6.4 °C increase of the global temperatures and a rise in

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the sea level of about 16.5 to 53.8 cm by 2100 (IPCC, 2007). A CO2 emission which is a global pollutant is the main greenhouse gas that causes 58.8% of global warming and climate change (The World Bank, 2007a). Rapid increase of CO_2 emissions is mainly the result of human activities due to the development and industrialization over the last decades.

Combined global land and ocean surface temperature for January 2010 on the average was 0.60°C (1.08°F) above the 20th 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^{th} century average of 2.8°C (37.0°F). Global warming is partly resulting 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. The issue of environmental pollutants is in a progressive trend in developing countries as they require more energy consumption for higher economic development. Consequently, they suffer from more environmental problems.

Rapid increase of CO_2 emissions is mainly the result of human activities due to the development and industrialization over the last decades. In this subject one strand of literature focuses on testing the growth and CO_2 emissions nexus under testing the Environmental Kuznets Curve (EKC) hypothesis which proposes a U-type relationship between environmental quality and income growth to determine whether continued increase in economic growth will eventually undo the environmental impact of the early stages of economic development or not. EKC hypothesis was first tested by Grossman and Krueger (1991). A great number of related studies are available in Dinda (2004). Some recent studies are Dinda and Coondoo (2006), Fodha and Zaghdoud (2010) and Narayan and Narayan (2010) with their results differ substantially and are inconclusive.

Fossil Fuels are fuels formed by natural processes such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years. Fossil fuels are hydrocarbons and include coal, oil (petroleum), and natural gas. Fossil fuels are nonrenewable resources because they take millions of years to form, and reserves are being depleted much faster than new ones are being made. 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 Bandypadhyay, 1992; Hettige *et al.,* 1992; Diwan and Shafik, 1992).

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_2 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_2 emission through industrial growth enhancing-affect.

1.1 Environmental Kuznets Curve

The Environmental Kuznets Curve (Kuznets, 1955) is named after Russian American economist, Simon Smith Kuznets. He hypothesized environmental degradation and pollution increase in the early stage of economic development and that after reaching a certain level of economic growth environmental degradation will decrease as the economy grows. This implies that high income levels of economic growth lead to improvement in the environment condition. Therefore some economists believe that economic growth is a natural remedy for the environmental pollution and depletion of natural resources (Beckerman, 1992).

The Environmental Kuznets Curve (EKC) hypothesis claims that an inverted U-shaped relation exists between income and environmental pollution or the usage of natural resources such as forest resources. Early empirical studies demonstrate the EKC between income and environmental pollutants such as sulfur dioxide (SO_2), nitrogen oxide (NOX), and suspended particulate matter (SPM).[1]

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.

The literature on the EKC is voluminous. The EKC concept became widely discussed starting in the early 1990s with background study of the World Development Report (Shafil and Bandyopadhyay, 1992) and study of potential impact of NAFTA[2] (Grossman & Krueger, 1991). The inverted "U" shaped relationship of the environment degradation and income is supported by enough theoretical evidences. According to EKC concept, Carbon dioxide CO_2 emission (the indicator we used as environmental pollution) is expected to have a positive relationship with the level of economic growth.

1.2 Environmental Kuznets Curve and Pakistan

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_2 emitting sector compared to industrial production. Furthermore, Pakistan is a net importer of fertilizer and other chemical products considered highly emitting

[1]See Grossman and Krueger (1993, 1995); Selden and Song (1994); Suri and Chapman (1998); and Agras and Chapman (1999).
[2]North American Free Trade Agreement

contaminated gases. Hence, it is assumed that foreign trade does not contribute significantly towards CO_2 emissions in Pakistan.

The Environmental Kuznets Curve hypothesis is tested using the impact of foreign trade, urbanization and mechanization on the causal linkages of CO_2 emission, economic growth and energy consumption. Halicioglu (2009) discussed for the first time, the effects of the foreign trade on the nexus of CO_2 emission, economic growth and energy consumption.

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 led 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 CO_2 emissions[3]. A considerable share of CO_2 emissions is coming from natural gas mainly by the electricity production and coal consumption produces more than 50% of CO_2 emissions of natural gas. In 2005, 0.4% of the world total CO_2

[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.

emissions were produced by Pakistan and this "contribution" is worsening day by day.

The main objective of the study is to analyze the impact of fossil fuel energy consumption on CO2 emissions for Pakistan from 1980-2010. We can discuss the broad objectives as follow;

- To empirically examine the environmental Kuznets curve for Pakistan.
- To test the robustness of environmental Kuznets curves in the presence of other variables.
- To empirically analyze the factors that affects the fossil fuel energy consumption in short run as well as long run.
- To propose suitable policy implications based on empirical findings.

2. Literature Review

Shafik (1994) and Holtz-Eakin and Selden (1995) conclude that the amount of CO_2 emissions monotonically increases with per capita income. Selden and Song (1994) using unbalanced data from 130 countries to examine the relationship between real income per capita and CO_2 emissions and confirmed environmental Kuznets hypothesis after investigating the relationship between economic growth and a set of energy pollutants i.e. SO_2, NOX, CO_2. Lanoie *et al.,* (1998) note that financial market can help reduce CO_2 emissions by providing incentives to firms for compliance of environmental regulations.

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_2 emissions. They found that the use of advanced capital intensive techniques help environment and supports EKC relation. Dasgupta *et al.,* (2004) find that firms in Korea lose market value if their names are made public for violation of environmental regulations. Liu (2005) studies the 24 OECD nations using the panel data. By analyzing the GDP and CO_2 emissions in a simultaneous equation system and considering each country's energy consumption as well as income, he concludes that the EKC for CO_2 exists.

Richmond and Kaufman (2006), considered nuclear power generation and investigated the EKC for CO_2 using the panel data of OECD countries and non-OECD countries. They point out that there is limited support of the EKC in the case of OECD countries, but not in the case of non-OECD countries. However, the time series analysis on the EKC for an individual country may be able to clarify the effects. 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.

Alam, *et al.,* (2007) applied Johansen multivariate cointegration approach to examine long run impact of population growth, income per capita, energy intensity and urbanization on environmental degradation in Pakistan. They found that a 1% increase in per capita GDP and energy intensity growth leads to 0.84% and 0.24% increase in the growth rate of CO_2 and CO_2 emissions. Soytas, *et al.,* (2007) found no causality relation from income to CO_2 emissions, including the energy consumption in the analysis on the EKC in the U.S.

Ang (2007) applied ARDL bounds testing approach to cointegration for France and found stable long run relation between economic growth and CO_2 emission. He found causality runs from economic growth to energy consumption and CO_2 emissions in the long run but in the short run energy consumption causes economic growth. He argued that the EKC hypothesis is satisfied in France, by including energy use in the commercial field. Study also focuses on nuclear power generation, which addresses the production side of electrical energy.

Claessens and Feijen (2007) posit that good governance and financial development can improve environmental quality. Financial development makes it easier to adopt advanced technology in energy sector which helps reduce CO_2 emissions significantly (Kumbaroglu *et al.,* 2008). The authors suggested that investment in technology improves the efficiency of energy sector.

Chebbi and Boujelbene (2008) explored the long and short-run linkages between economic growth, energy consumption and CO_2 emission using Tunisian data from 1971 to 2004. Findings clear that economic growth; energy consumption and CO_2 emission are related in the long-run and provide some evidence of inefficient use of energy in Tunisia, since environmental pressure tends to rise faster than economic growth. In the short run, results support the argument that economic growth exerts a positive “causal” influence on energy consumption growth. In addition, results from impulse response do not confirm the hypothesis that an increase in pollution level induces economic expansion.

Ang (2008) found positive link between GDP per capita, energy consumption, CO_2 emissions for Malaysia. Causality runs from output to energy consumption not only in the short, but also in the long run. Song *et al.,* (2008) used panel cointegration to Chinese provincial level data and found long run relationship between economic growth and indicators of CO_2 emissions i.e. waste gas, waste water, solid wastes etc., which confirms an inverted U relationship. Wagner (2008) also found an inverted U-relation by using panel and cross-section data between economic growth and energy pollutants. i.e. CO_2 and SO_2.

Halicioglu (2009) examined the relationship between income per capita, carbon emissions, and 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_2 emissions are the main contributors to economic growth in the long run. Halicioglu (2009) applied ARDL approach of cointegration in a log-linear quadratic equation among CO_2 emission, energy consumption, and economic growth in order to test the validity of EKC for Turkey. Results suggested that the most significant variable in explaining the carbon emissions in Turkey is income followed by energy consumption and foreign trade.

Jalil and Mahmud (2009) found uni-directional causality running from economic growth to CO_2 emissions in China. The results of the study also indicate that the carbon emissions are mainly determined by income and energy consumption in the long-run. Moreover trade has a positive but statistically insignificant impact on CO_2 emissions.

Bhattacharyya and Ghoshal, (2009) explore the relationship among CO_2 emissions, population and per capita GNP using data from 25 countries. They found causality runs from energy consumption to CO_2

emissions for most countries, also higher population growth raises CO_2 emissions.

Lean and Smyth (2009, 2010) examined the relation between electricity consumption, CO_2 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_2 emissions. The CO_2 emissions and GDP per capita relation supports the existence of EKC.

Apergis and Payne (2009) extended the work by Ang (2007) to examine the causality between CO_2 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_2 emissions.

Akbostanci *et al.,* (2009) examined Turkish data but did not find support for the EKC. Esmaeili *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.

Tamazian *et al.,* (2009) examined the impact of economic and financial development on CO_2 emissions for BRIC nations plus the United States and Japan. They found that both the factors help reduce CO_2 emissions. They found that trade liberalization and financial sector reforms help reduce CO_2 emissions**.**

Iwata, *et al.,* (2009) estimated the Environmental Kuznets Curve for France from 1960 to 2003 by using autoregressive distributed lag (ARDL) approach to cointegration and also investigate the granger causality on CO_2 emissions, real GDP, consumption per capita energy use (measured as kg of oil equivalent per capita), total trade as the percentage of GDP and Electricity produced from the nuclear source. Results clears that the effects of nuclear energy on CO_2 emissions are significantly negative both in the short run and long-run while, the effects of trade or energy consumption are insignificant and the causality tests confirm the uni-direction running from income and nuclear energy to CO_2 emissions statistically provides evidence on the important role of nuclear energy in reducing CO_2 emissions. This implies that although economic growth causes more CO2 emissions, any effort to reduce them does not restrain the development of the economy.

Iwata, *et al.,* (2010) as well as the two previous studies supported the EKC hypothesis in the case of France. They found evidence of statistically significance for the coefficient of energy consumption just in the short-run. Fodha *et al.,* (2010) examined the relationship between energy emissions (CO_2 and SO_2) and GDP per capita for Tunisia. They found evidence in supports an EKC between economic growth and SO_2 emissions, and but not with regard to CO_2 emissions. Although research has mainly focused on the relationship between economic growth and indicators of energy emissions e.g. CO_2, SO_2, and NOX, not much attention has been paid to the role of financial development in reducing CO_2 emissions.

Tamazian and Rao (2010) applied GMM approach to find the effect of institutional, economic and financial development on CO_2 emissions for the transitional economies. They found that these factors help lower CO_2 emissions. They also found support in favor of EKC. Yuxiang and Chen (2010) found that financial development reduces industrial pollutants by using provincial data from China. 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_2 emissions. The results suggest that financial development in China has helped improve environment.

Shanthini and Perera (2010) found the existence of a cointegrating relationship between Australia's fossil-fuel based CO_2 emission per capita and gross domestic product (GDP) per capita measured in market exchange rates, which is the proxy used for economic prosperity from 1960 to 2007. Results exhibit a tendency to move together suggesting the probable existence of a cointegrating relationship between CO_2 emissions per capita and GDP per capita. Both the CO_2 emissions per capita growth and the GDP per capita growth slowdown during the1970s, which is the decade of two major oil shocks, and that the emission appear to flatten out since 2000. The long run income elasticity is estimated to be as high as 0.7, and 36% of any deviation from the long run equilibrium is corrected within a year. In the short-run, 1% increase in GDP per capita growth in the previous year leads to 0.33% increase in the current growth in CO_2 emission per capita. They also hypothesize that the inclusion of oil price might strengthen the long-run equilibrium relationship, even though the impact of oil price on CO_2 emissions per capita would be many folds smaller than the impact of GDP per capita on it.

Zhang (2011) reinvestigated financial development and CO_2 emissions nexus 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 CO_2 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.

Shahbaz, *et al.,* (2011) explores the existence of a long run equilibrium relationship among CO_2 emissions, financial development, economic growth, energy consumption and population growth for Pakistan from 1974 to 2009. ARDL bounds testing approach to cointegration is used and the results confirmed a long run relation among these variables. Financial development helps to reduce CO_2 emissions. The main contributors to CO_2 emissions are economic growth, population growth and energy consumption. Results also 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.

Saboori, *et al.,* (2011) examines the dynamic relationship among carbon dioxide CO_2 emissions, economic growth, energy consumption and foreign trade based on the environmental Kuznets curve (EKC) hypothesis for Indonesia from 1971 to 2007. The Auto-regressive distributed lag (ARDL) results do not support the EKC hypothesis, which assumes an inverted U-shaped relationship between income and environmental degradation. The long-run results indicate that foreign trade is the most significant variable in explaining CO_2 emissions in Indonesia followed by Energy consumption and economic growth.

Saboori and Soleymani (2011) examines the dynamic relationship among carbon dioxide CO_2 emissions, economic growth and energy consumption based on the environmental Kuznets curve (EKC) hypothesis for Iran during the period 1971 to 2007. Auto regressive distributed lag (ARDL) results suggest that the existence of three forms of long-run relationship among variables when CO_2 emissions, economic growth and energy consumption are the dependent variables. The results do not support the EKC hypothesis which assumes an inverted U-shaped relationship between income and environmental degradation. The long-run results indicate energy consumption has a positive and significant impact on CO_2 emissions.

Anees and Ahmed (2011) used data on Carbon Dioxide emission, economic growth, energy consumption, openness for foreign trade, urbanization, industrial growth and agriculture growth on Pakistan from 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_2 affect economic growth, agriculture and industrial growth in the long run. It is also evident that energy consumption uni-directional 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.

Tiwari (2011) examined causality using static and dynamic frame work by using energy consumption, CO_2 emission and economic growth for India from 1971 to 2005. Study found that CO_2 Granger-causes GDP while energy consumption does not Granger-cause GDP, GDP does not Granger-cause CO_2 while energy consumption Granger-causes CO_2 emissions, and CO_2 emissions Granger-causes energy consumption but

GDP does not Granger-causes CO_2 emissions. This implies that India should opt for policies that stress on energy conservation and efficient utilization of energy.

Tiwari (2011) examined the causality in both static and dynamic framework between energy consumption, CO_2 emissions and economic growth in India using Granger approach in VAR framework from 1971 to 2007. Results found that from the VAR analysis; energy consumption, capital and population Granger-cause economic growth not the vice versa. IRFs and VDs analysis results indicate that CO_2 emissions have positive impact on energy use and capital but negative impact on population and GDP. Energy consumption has positive impact on CO_2 emissions and GDP but its impact is negative on capital and population. This implies that, in the framework of production function, capital and population/labour has been rapidly substituted by energy use in the production process.

Essien (2011) used the Standard Version of Granger and the Restricted VAR Model (VECM) for analyzing the short and long run CO_2 emission patterns and the relationship between economic growth and CO_2 emissions in Nigerian economy over the period of 1980 to 2009. He examines the impacts of selected variables such as GDP per capita, electricity per capita, natural gas per capita, crude oil per capita, and fuel woods per capita on the CO_2 emission. The result suggests that there exists a long run relationship among the variables. Results reveals that electricity and gas consumption cause economic growth both in the short and long run but only fuel woods influences it in the long run while, it provide evidence that natural gas influences carbon emissions in the long run while fuel woods influences carbon emissions in the short run.

Alam, *et al.,* (2012) investigated the possible existence of dynamic causality between energy consumption, electricity consumption, carbon emissions and economic growth in Bangladesh from 1972 to 2006. Results indicate that uni-directional causality exists from energy consumption to economic growth both in the short and the long-run while a bi-directional long run causality exists between electricity consumption and economic growth but no causal relationship exists in short- run. A uni-directional causality runs from energy consumption to CO_2 emission for the short-run but feedback causality exists in the long-run.

Hedi, *et al.,* (2012) extended the recent findings of Liu (2005), Ang (2007), Apergis *et al.,* (2009) and Payne (2010) by implementing panel unit root tests and cointegration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA)[1] over the period 1981 to 2005. Results showed that in the long-run energy consumption has a positive significant impact on CO_2 emissions but providing poor evidence in support of the EKC hypothesis. Findings suggest that not all MENA countries need to sacrifice economic growth to decrease their emission levels as they may achieve CO_2 emissions reduction via energy conservation without negative long-run effects on economic growth.

3. Methodology and Model Specification

3.1 Environment Kuznets Curve

Following the approach adopted by Ang (2007), Acaravci and Ozturk (2010), and Lean and Smyth (2010), the long-run relationship between fossil fuel energy consumption, economic growth and carbon emissions can be specified as follows:

$$CO2_t = \alpha_0 + \alpha_1 FFEC_t + \alpha_2 PCRGDP_t + \alpha_3 PCRGDP^2{}_t + \varepsilon_t \quad (1)$$

Where CO_2 is carbon dioxide emissions, FFEC is fossil fuel energy consumption; PCRGDP is per capita real GDP and also its square used as a proxy for economic growth. The expected sign of fossil fuel energy consumption is positive. The expected sign of per capita real GDP is positive while of its square is negative in order to reflect the inverted U-shape pattern.

In order to test the robustness of inverted U hypothesis we extend our model by incorporating some other variables;

$$CO2_t = \beta_0 + \beta_1 FFEC_t + \beta_2 PCRGDP_t + \beta_3 PCRGDP^2{}_t + \beta_4 INDVAD + \beta_5 FD + \beta_6 TO + \upsilon_t \quad (2)$$

[1]Algeria, Bahrain, Egypt, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, Saudi Arabia, Tunisia, and UAE

Where INDVAD is industrial value added that represents the industrial sector growth, while FD is financial development and TO is trade openness. Industrial value added is expected to have positive sign while financial development is ambiguous. Trade openness is expected to affect the CO_2 emission positively.

3.2 Energy Consumption

To test the long run determinants of energy consumption we have specified the following equation;

$$FFEC_t = \delta_0 + \delta_1 RGDP_t + \delta_2 GFCF_t + \delta_3 POP_t + \delta_4 MX + \delta_5 MM + \varepsilon_t \quad (3)$$

Where FFEC is fossil fuel energy consumption, RGDP is real GDP used as a proxy for economic growth, GFCF is investment, POP is population, MX represents manufacture exports and MM represents manufacture imports. Economic growth, investment, population and manufacture export are expected to have positive sign while manufacture import is ambiguous.

Table 1: Description and Sources of Variables

Variable	Description
CO_2	Log of CO_2 emissions (metric tons per capita) **Source:** World Development Indicators (WDI)
FFEC	Fossil fuel energy consumption (% of total) **Source:** World Development Indicators (WDI)
PCRGDP	Log of Per capita real GDP **Source:** International Financial Statistics (IFS)
$PCRGDP^2$	Square of Per capita real GDP
INDVAD	Industrial value added (% of GDP) **Source:** World Development Indicators (WDI)
FD	Log of credit to private sector **Source:** State Bank of Pakistan (SBP)
MX	Manufacture exports (% of merchandise exports) **Source:** World Development Indicators (WDI)
RGDP	Log of real GDP deflated by CPI (2005-=100) **Source:** International Financial Statistics (IFS)
GFCF	Gross fixed capital formation (% of GDP) **Source:** World Development Indicators (WDI)
POP	Log of Population (millions) **Source:** International Financial Statistics (IFS)
MM	Manufacture imports (% of merchandise imports) **Source:** World Development Indicators (WDI)
TO	Total trade as % of GDP **Source:** World Development Indicators (WDI)

3.3 Unit Root Test: Augmented Dickey Fuller Test

An augmented Dickey-Fuller test is a test for a unit root in a time series sample. An augmented Dickey-Fuller test is a version of the Dickey-Fuller test for a larger and more complicated set of time series models. When the series of error term is not white noise then in that we keep on introducing lag terms of dependent variable until we get white noise series of error terms.

The general form of ADF test can be written at level and first difference as follows:

$$\Delta Y_t = ay_{t-1} + \sum_{i=1}^{n} \beta \Delta Y_{t-1} + \delta + Y_t + \xi_t \qquad \textbf{(4)}$$

$$\Delta\Delta\ Y = a_1 \Delta Y_{t-1} + \sum_{i=1}^{n} \beta \Delta\Delta\ Y_{t-1} + \delta + \gamma_t + \xi_t \qquad \textbf{(5)}$$

3.4 Co-integration Test

Co-integration is an econometric technique for testing the correlation between non-stationary variables. If two or more series are themselves non-stationary, but a linear combination of them is stationary, then series are called co-integrated. The purpose of co-integration is to make OLS (in first differences) a BLUE. Standard regression analysis is said to be best, linear unbiased. The co-integration approach generally solves the problem by expanding the model in to a system of equation in which each variable may influence every other variable. The statistical significance of the dependence of each variable on every other variable can be tested. If two or more series are individually integrated (in the time series sense) but some linear combination of them has a lower order of integration, then the series are series are said to be co-integrated. A common example is where the individual series are first – order integrated I(1) but some (co integrated)vector of coefficients exists to from a stationary linear combination of them for instance, a stock market index and the price of its associated futures contract move through time, each roughly following a random walk. Testing the hypothesis that there is a statistically significant connection between the futures price and the spot price could now be done by testing for the existence of a co -integrated combination of the two series.(if such a combination has a low order of integration in particular if it is I (0), this can signify an equilibrium relationship between the original series, which are said to be co-integrated).

3.5 Vector Error Correction Model

An error correction model is a dynamic system with the characteristics that the deviation of the current state from its long-run relationship will be fed into its short-run dynamics. An error correction model is not a model that corrects the error in another model. A Vector Error Correction Model (VECM) can lead to a better understanding of the nature of any nonstationarity among the different component series and can also improve longer term forecasting over an unconstrained model. The VECM form is written as:

$$\Delta y_t = a_0 + \sum_{i=1}^{m} \beta_i \Delta y_{t-i} + \sum_{i=0}^{m} \delta_i \Delta x_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta z_{t-i} + \lambda ECT_{t-1} + \xi_t \qquad \textbf{(6)}$$

The error correction term indicates the speed of adjustment to restoring equilibrium in the dynamic model. The ECM co-efficient shows how quickly/slowly variables return to equilibrium and it should have a statistically significant co-efficient with a negative sign.

3.6 Granger Causality

In economics, systematic testing and determination of causal directions only became possible after an operational framework was developed by Granger (1969) and Sims (1972). Their approach is crucially based on the axiom that the past and present may cause the future but the future cannot cause the past[3]. In econometrics the most widely used operational definition of causality is the Granger definition of causality, which is defined as follows:

"X is a Granger cause of Y (denoted as X→Y), if present y can be predicted with better accuracy by using past values of x rather than by not doing so, other information being identical"[4].

To test the bi-variate causality relationships the following causal model is used:

[3]Granger, (1980)
[4]Charemza and Deadman (1992)

$$x_t = \sum_{j=1}^{p} a_i x_{t-j} + \sum_{j=1}^{p} b_i y_{t-j} + u_t$$
$$y_t = \sum_{j=1}^{p} c_i x_{t-j} + \sum_{j=1}^{p} d_i y_{t-j} + v_t \quad \textbf{(7, 8)}$$

Where *Ut* and *Vt* are two uncorrelated white-noise series and p is the maximum number of lags.

4. Results and Discussions

Table 1: Results of Unit Root Test (ADF- Test)

Variables	**Level**			**1st difference**			**order of integration**
	Intercept	Trend and intercept	none	Intercept	Trend and intercept	none	
TO	-0.763653 (-2.96) LAG(0)	-2.149911 (-3.56) LAG(0)	-1.65445 (-1.96) LAG(0)	-5.14054* (-2.96) LAG(0)	-5.05514* (-3.56) LAG(0)	-4.6966* (-1.96) LAG(0)	1(1)
CO_2	-0.429700 (-2.96) LAG(0)	-2.684728 (-3.56) LAG(0)	-1.05273 (-1.96) LAG(0)	-7.27443* (-2.96) LAG(0)	-7.15370* (-3.56) LAG(0)	-4.4043* (-1.96) LAG(0)	1(1)
FFEC	-1.282973 (-2.96) LAG(0)	-2.192627 (-3.56) LAG(0)	-1.63578 (-1.96) LAG(0)	-5.27039* (-2.96) LAG(0)	-5.30489* (-3.56) LAG(0)	-3.8114* (-1.96) LAG(0)	1(1)
INDVAD	-1.776672 (-2.96) LAG(1)	-2.345894 (-3.56) LAG(1)	-0.51290 (-1.96) LAG(0)	-5.98219* (-2.96) LAG(0)	-5.85061* (-3.56) LAG(0)	-6.0549* (-1.96) LAG(0)	1(1)
MM	-2.102556 (-2.96) LAG(0)	-2.170191 (-3.56) LAG(0)	-0.52357 (-1.96) LAG(1)	-6.03881* (-2.96) LAG(0)	-6.16942* (-3.56) LAG(0)	-6.1414* (-1.96) LAG(0)	1(1)
MX	-2.965731 (-2.96) LAG(0)	-1.208926 (-3.56) LAG(0)	-0.73884 (-1.96) LAG(1)	-5.33068* (-2.96) LAG(0)	-7.22322* (-3.56) LAG(0)	-5.2478* (-1.96) LAG(0)	1(1)
PCRGDP	-0.925548 (-2.96) LAG(0)	-1.320890 (-3.56) LAG(0)	-1.14490 (-1.96) LAG(0)	-5.40851* (-2.96) LAG(0)	-5.68580* (-3.56) LAG(0)	-3.7570* (-1.96) LAG(0)	1(1)
RGDP	-1.232317 (-2.96) LAG(0)	-0.874471 (-3.56) LAG(0)	-1.49878 (-1.96) LAG(0)	-4.90488* (-2.96) LAG(0)	-5.99628* (-3.56) LAG(0)	-2.7765* (-1.96) LAG(0)	1(1)
POP	-2.484547 (-2.96) LAG(3)	-2.188403 (-3.56) LAG(3)	-0.34365 (-1.96) LAG(3)	-3.46688* (-2.96) LAG(2)	-3.587844 (-3.56) LAG(2)	-3.3622* (-1.96) LAG(2)	1(1)
GFCF	-2.913031 (-2.96) LAG(2)	-3.189074 (-3.56) LAG(1)	-0.65837 (-1.96) LAG(1)	-3.36582* (-2.96) LAG(0)	-3.35304* (-3.56) LAG(0)	-3.4127* (-1.96) LAG(0)	1(1)
FD	-1.105499 (-2.96) LAG(3)	-3.14839 (-3.56) LAG(3)	-1.45771 (-1.96) LAG(3)	-4.46427* (-2.96) LAG(2)	-4.52320* (-3.56) LAG(2)	-2.6397* (-1.96) LAG(2)	1(1)

Note:*Denotes the rejection of hypothesis at 5%level of significance

We test the null hypothesis of unit root against the alternative. The results of our study comprise that all variables have a unit root in their levels indicating that the levels are non-stationary. The first differenced series however, clearly rejects unit roots suggesting that the differenced variables are all stationary.

4.1 Environment Kuznets Curve for CO_2 emission

As results of unit root test show that all the variables are I (1). So we use Johansson co-integration test to test the long run relationship between inflation and its determinants. As the first step in co-integration we test the lag order of model. We determine the lag order through AIC (Akaike information criterion) using VAR (vector auto regressive). In the second step we test the null hypothesis of no co-integration against the alternative through maximum Eigen statistics.

Table2: Johansen Cointegration Tests Results

Lags interval: 1 to 1				
Eigenvalue	**Likelihood Ratio**	**5 Percent Critical Value**	**1 Percent Critical Value**	**Hypothesized No. of CE(s)**
0.7164	88.03	53.12	60.16	None **
0.5789	51.48	34.91	41.07	At most 1 **
0.5343	26.40	19.96	24.60	At most 2 **
0.1359	4.23	9.24	12.97	At most 3

Note: *, (**) denotes rejection of the hypothesis at 5% (1%) significance level. L.R. test indicates 3 cointegrating equation(s) at 5% significance level

Results of Maximum Eigen statistics show the evidence of four long run co integration relationships in our model. We reject the null hypothesis of two co integrating relations against alternative of three cointegrating relations.

4.2 Normalized Cointegrating Coefficients

$$CO2_t = \alpha_0 + \alpha_1 FFEC_t + \alpha_2 PCRGDP_t + \alpha_3 PCRGDP^2{}_t + \varepsilon_t \quad (9)$$

Table 3: Dependent Variable: CO_2

Variables	Coefficients	Standard Error	t. Statistics
FFEC	0.845970	0.02760	30.6485*
PCRGDP	0.00298	0.00012	24.8333*
PCRGDP^2	-0.766665	0.33556	2.28473**
C	4.480726	0.16164	27.72404

Note: *, ** show the significance at 1 and 5 %, respectively

Fossil fuel energy consumption positively affects the CO_2 emission as expected. A 1 % increase in Fossil fuel energy consumption brings 0.84% increase in CO_2 emission. The higher level of energy consumption results in greater economic activity and stimulates CO_2 emissions.

Per capita real GDP positively affects the CO_2 emission. The statistically significant sign of Per capita real GDP square confirm the declining of CO_2 emission at higher level of income which provides the proof for the existence of environmental Kuznets curve. That the level of CO_2 emission initially increases with income, until it reaches maximum, then it declines. In the early stages of the economic process, there is abundance of natural resource stock and a low production of wastes because of low economic activity. As industrialization takes off, resource depletion and waste production accelerate. At this phase of transition from agriculture to industry, industrialization of the production process creates a positive relationship between per capita incomes (or else economic growth) with environmental degradation, in a general sense. At higher levels of economic development, the production process of the economy becomes more information based and the service sector is boosted. This shift in the composition of production, combined with improvements in technology and increased demand for environmental quality, results in a leveling-off and a steady decline of environmental degradation.

4.3 Error Correction Model

After Estimating long run coefficients we move toward VAR (vector error correction) model.

$$\Delta CO_t = \alpha_0 + \alpha_1 \sum_{i=1}^{n} \Delta CO_{t-i} + \alpha_2 \sum_{i=0}^{n} \Delta FFEC_{t-i} + \alpha_3 \sum_{i=0}^{n} \Delta PCRGDP_{t-i} + \alpha_4 \sum_{i=0}^{n} \Delta PCRGDP^2_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad (10)$$

Table 4: Dependent variable: ΔCO_2

Variables	Coefficients	Standard Error	t. Statistics
ECT(-1)	**-0.799072**	0.14648	-5.45519*
D(CO_2(-1))	0.257076	0.11794	2.17980**
D(FFEC(-1))	-3.71E-07	0.00045	-0.00083
D(PCRGDP(-1))	1.234524	0.92911	1.32871
D($PCRGDP^2$(-1))	-2.814629	1.35902	-2.07108**
C	0.030004	0.00561	5.34389
R-squared	0.714738	S.E. equation	0.014255
Sum sq. resides	0.004674	Log likelihood	85.48031

Note: *, ** show the significance at 1 and 5 % respectively

Short run co-efficient estimates obtained from the ECM indicate that the estimated lagged error correction term (EC_{t-1}) is negative and significant. The feedback coefficient is -0.79, suggesting that about79 percent disequilibrium in the previous year is corrected in the current year. Short run results show that previous period's carbon dioxide emission and per capita real GDP positively affects the CO_2 emission in current period. Previous period's energy consumption and per capita GDP square negatively affectCO_2 emission in current period. Most of the variables lose their significance in short run.

4.4 Robustness check for the environment Kuznets Curve for CO_2 emission

We test the null hypothesis of no co-integration against the alternative through maximum Eigen statistics.

Table 5: Johansen Cointegration Tests Results

Lags interval: 1 to 1				
Eigenvalue	**Likelihood Ratio**	**5 Percent Critical Value**	**1 Percent Critical Value**	**Hypothesized No. of CE(s)**
0.8808	185.42	131.70	143.09	None **
0.7529	123.73	102.14	111.01	At most 1 **
0.6248	83.18	76.07	84.45	At most 2 *
0.5441	54.75	53.12	60.16	At most 3 *
0.4778	31.97	34.91	41.07	At most 4
0.2080	13.12	19.96	24.60	At most 5
0.1971	6.36	9.24	12.97	At most 6

Note: *(**) denotes rejection of the hypothesis at 5% (1%) significance level. L.R. test indicates 4 cointegrating equation(s) at 5% significance level

Results of Maximum Eigen statistics show the evidence of four long run co integration relationships in our model. We reject the null hypothesis of three co integrating relations against alternative of four co integrating relations.

4.5 Normalized Cointegrating Coefficients

$$CO2_t = \beta_0 + \beta_1 FFEC_t + \beta_2 PCRGDP_t + \beta_3 PCRGDP^2{}_t + \beta_4 INDVAD + \beta_5 FD + \beta_6 TO + \upsilon_t \quad (11)$$

Table6: Dependent Variable: CO_2

Variables	Coefficients	Standard Error	t. Statistics
FFEC	1.178385	0.10824	10.88673*
PCRGDP	0.01408	0.00144	9.7777*
$PCRGDP^2$	-0.085049	0.34868	-0.24391
INDVAD	0.011705	0.00244	4.79713*
FD	-0.006184	0.00239	-2.58744**
TO	0.003447	0.00088	3.90909*
C	5.017042	1.44981	3.46047

Note: *,** show the significance at 1 and 5 % respectively

We re-estimate the previous equation by including some other variables to test the robustness of environmental Kuznets hypothesis. Both the variables have expected signs but per capita real GDP lose its significance when we include some other variables. It shows that higher income is not the only factor to control the CO_2 emission some other factors are also important. Moreover in developing countries a very small proportion of income is spent to control the environmental degradation.

Increase in the size of the economy (scale effect) is likely to increase pollution. Production and industrial activities involve energy as an essential input. Energy is one of the main resources of industrialization. As industrial sector expand energy consumption increases that lead to increase environmental degradation. A 1 % increase in the share of industrial sector increases the CO_2 emission by 0.011%.

Developing countries are mostly net exporter of pollution-intensive goods (Grossman and Krueger, 1995) so trade openness results in the development of pollution-intensive industries and environmental degradation in developing countries. Natural resources are depleted due to international trade. This depletion of natural resources raises CO_2 emissions and causes environment quality worsened (e.g. Schmalen; Copeland and Taylor, Chaudhuri and Pfaff). A 1 % increase in trade openness increases the CO_2 emission by 0.003%.

Financial development reduces CO_2 emissions through research and development enhancing effect due to economic growth. 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). Financial development may generally boost research and development(R & D) activities and sequentially improve economic activities, and hence, influence environmental quality (Frankel and Romer, 1999). A 1 % increases in financial development decreases the CO_2 emission by 0.006%.

4.6 Error Correction Model

After Estimating long run coefficients we move toward VAR (vector error correction) model.

$$\Delta CO2_t = \beta_0 + \beta_1 \sum_{i=1}^{n} \Delta CO2_{t-i} + \beta_2 \sum_{i=0}^{n} \Delta FFEC_{t-i} + \beta_3 \sum_{i=0}^{n} \Delta PCRGDP_{t-i} + \beta_4 \sum_{i=0}^{n} \Delta PCRGDP^2{}_{t-i} + \quad (12)$$
$$\beta_5 INDVAD + \beta_6 FD + \beta_7 TO + \eta ECT_{t-1} + \upsilon_t$$

Table7: Dependent variable: ΔCO_2

Variables	**Coefficients**	**Standard Error**	**t. Statistics**
ECT(-1)	**-0.4392**	0.1235	-3.55*
D(CO_2(-1))	0.3701	0.2314	1.59***
D(FFEC(-1))	0.3498	0.6126	0.57
D(PCRGDP(-1))	0.0087	0.0042	2.03**
D($PCRGDP^2$(-1))	-1.4839	0.8217	-1.81***
D(INDVAD(-1))	0.0045	0.0055	0.81
D(FD(-1))	-0.0049	0.0066	-0.75
D(TO(-1))	-0.0005	0.0014	-0.35
C	0.0072	0.0128	0.56
R-squared	0.6480	S.E. equation	0.018
Sum sq. resides	0.0057	Log likelihood	82.43

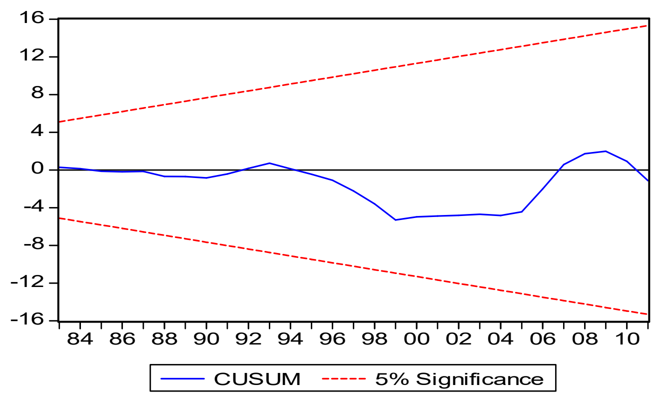
Note: *,**,*** show the significance at 1, 5 and 10 % respectively.

Short run co-efficient estimates obtained from the ECM indicate that the estimated lagged error correction term (EC_{t-1}) is negative and significant. The feedback coefficient is -0.43, suggesting that about 43 percent disequilibrium in the previous year is corrected in the current year. Short run results show that previous period's carbon dioxide emission, energy consumption, per capita real GDP and industrial value added positively affect the CO_2 emission in current period. Previous period's financial development, trade openness and square of per capita real GDP negatively affect CO_2 emission in current period. Most of the variables lose their significance in short run.

4.7 Stability test

The stability test is conducted by employing the commutative sum of recursive residuals (CUSUM). The CUSUM Plotted against the critical bound of the 5 percent significance level show that the model is stable overtime.

Figure 1: The CUSUM test Plot



4.8 Energy Consumption

In the second step we test the null hypothesis of no co-integration against the alternative through maximum Eigen statistics.

Table 8: Johansen Cointegration Tests Results

Lags interval: 1 to 1				
Eigenvalue	**Likelihood Ratio**	**5 Percent Critical Value**	**1 Percent Critical Value**	**Hypothesized No. of CE(s)**
0.9309	195.23	102.14	111.01	None **
0.7349	117.72	76.07	84.45	At most 1 **
0.7208	79.212	53.12	60.16	At most 2 **
0.4977	42.212	34.91	41.07	At most 3 **
0.3971	22.242	19.96	24.60	At most 4 *
0.2296	7.5648	9.24	12.97	At most 5

Note: *, (**) denotes rejection of the hypothesis at 5% (1%) significance level. L.R. test indicates 5 cointegrating equation(s) at 5% significance level

Results of Maximum Eigen statistics show the evidence of four long run co integration relationships in our model. We reject the null hypothesis of four co integrating relations against alternative of five cointegrating relations.

4.9 Normalized Cointegrating Coefficients

$$FFEC_t = \delta_0 + \delta_1 RGDP_t + \delta_2 GFCF_t + \delta_3 POP_t + \delta_4 MX + \delta_5 MM + \varepsilon_t \quad (13)$$

Table 9: Dependent Variable: FFEC

Variables	**Coefficients**	**Standard Error**	**t. Statistics**
RGDP	0.4663	0.0554	8.4110*
GFCF	0.6757	0.0640	10.557*
POP	1.7115	0.1260	13.583*
MX	0.0018	0.0003	5.3058*
MM	-0.0022	0.0004	-5.6307*
C	-3.6048	0.1605	22.457

Note: * show the significance at 1 % level of significance.

Energy consumption in developing economies, to a large extent is due to the higher growth rate of these economies. Higher growth rates put increasing pressure on energy consumption. Therefore GDP is positively related to energy consumption in developing economies. When growth rate increases remarkably, there will be an increasing pressure on resources. Therefore the demand for expert labor force, capital and equipment increases and more raw materials and energy is consumed. A 1 % increase in the real GDP increases the energy consumption by 0.46%.

Capital Intensive projects especially in infrastructure need high level of energy. A great amount of GFCF is related to on infrastructures and transportation which is remarkably influential on energy consumption in the country. A 1 % increase in investment increases the energy consumption by 0.67%.

As the population grows the need for energy consumption also increases. The size of population coupled with rise in GDP growth and higher per capita income creates demand for various products and this leads to increase in energy consumption. A 1 % increase in the population increases the energy consumption by 1.71%.

Manufacturing exports to different parts of the world requires higher energy consumption. The demand for these products is increasing at a faster rate and the clients being the developed economies. This is because of the availability of these products at a much cheaper rate because of the low cost resources in developing economies, especially in China. A 1 % increase in the Manufacturing exports increases the energy consumption by 0.001%.

Manufacture imports have negative effect on energy consumption. Increase in industrial products imports will lead to decrease in energy consumption if only the domestic produced goods which are the substitute for industrial imported goods consume higher energy levels. In such case, therefore industrial goods imports will reduce the energy consumption. A 1 % increase in the Manufacturing imports decreases the energy consumption by 0.002%.

4.10 Error Correction Model

After Estimating long run coefficients we move toward VAR (vector error correction) model.

$$\Delta FFEC_t = \delta_0 + \delta_1 \sum_{i=1}^{n} \Delta FFEC_{t-i} + \delta_2 \sum_{i=0}^{n} \Delta RGDP_{t-i} + \delta_3 \sum_{i=0}^{n} \Delta GFCF_{t-i} + \delta_4 \sum_{i=0}^{n} \Delta POP_{t-i} + \delta_5 MX + \beta_6 MM + \delta_7 MX + \phi ECT_{t-1} + \varepsilon_t \quad (14)$$

Table 10: Dependent variable: ΔFFEC

Variables	Coefficients	Standard Error	t. Statistics
ECT(-1)	**-0.4358**	0.3394	-3.2536*
D(FFEC(-1))	0.1304	0.2602	0.5012
D(RGDP(-1))	0.0188	0.2018	0.0932
D(GFCF(-1))	0.3042	0.2862	1.0630
D(POP(-1))	-0.4502	2.4372	-0.1847
D(MX(-1))	0.0007	0.0009	0.7162
D(MM(-1))	-0.0011	0.0014	-0.8663
C	0.0264	0.0652	0.4060
R-squared	0.6374	S.E. equation	0.01494
Sum sq. resids	0.0038	Log likelihood	88.4872

Note: *,** show the significance at 1 % and 5% level of significance.

Short run co-efficient estimates obtained from the ECM indicate that the estimated lagged error correction term (EC_{t-1}) is negative and significant. The feedback coefficient is -0.43, suggesting that about 43 percent disequilibrium in the previous year is corrected in the current year. Short run results show that previous period's energy consumption, economic growth, investment and manufacture export positively affect the energy consumption in current period. Previous period's manufacture imports and population negatively affect energy consumption in current period. Most of the variables lose their significance in short run.

4.11 Result of Causality test

Table11: Result of Granger Causality test

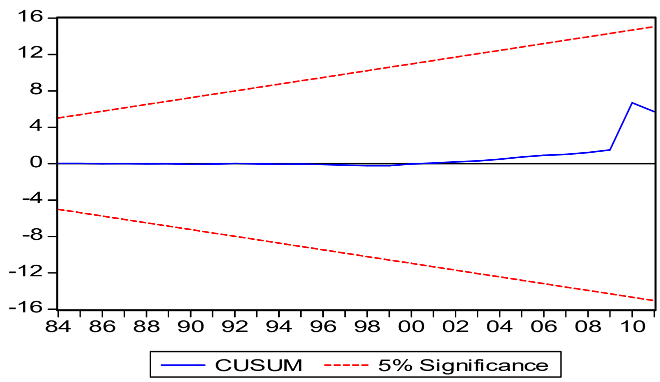
Pairwise Granger Causality Tests			
Sample: 1980 2010			
Lags: 1			
Null Hypothesis:	**Obs**	**F-Statistic**	**Probability**
RGDP does not Granger Cause FFEC	30	0.0794	0.7802
FFEC does not Granger Cause RGDP		0.2850	0.5977
GFCF does not Granger Cause FFEC	30	0.1934	0.6635
FFEC does not Granger Cause GFCF		0.2083	0.6517
POP does not Granger Cause FFEC	30	**11.101**	**0.0025**
FFEC does not Granger Cause POP		2.0405	0.1646
MX does not Granger Cause FFEC	30	**15.233**	**0.0006**
FFEC does not Granger Cause MX		0.7540	0.3928
MM does not Granger Cause FFEC	30	0.8281	0.3708
FFEC does not Granger Cause MM		0.7798	0.3850

Results of the pairwise granger causality test provide the evidence of unidirectional causality running from population to energy consumption and from manufacture exports to energy consumption. These results are explained in the energy consumption equation.

4.13 Stability test

The stability test is conducted by employing the commutative sum of recursive residuals (CUSUM). The CUSUM Plotted against the critical bound of the 5 percent significance level show that the model is stable overtime.

Figure 2: The CUSUM test Plot



5. Conclusion

The main objective of the present study is to test the impact of fossil fuel energy consumption on CO_2 emissions for Pakistan from 1980-2010. Our broad objectives are to test the inverted U relationship between economic growth and fossil fuel energy consumption and also the factors that affect the energy consumption in Pakistan. We use the Johenson Cointegration approach to test the long run relationship b/w the variables while Vector Error Correction model is used to test the short run relationship.

A log linear quadratic equation is specified to test the long run relationship among CO_2 emission, energy consumption and economic growth. Energy consumption negatively affects the CO_2 emission. Results support the inverted U shaped environmental Kuznets curve for Pakistan. In order to test the robustness of EKC we re-estimate the equation by adding some additional variables; industrial value added, financial development and trade openness. Results again proof the inverted U hypothesis. Industrial value added and trade openness positively affect the carbon di oxide emission while financial development reduces the CO_2 emission.

Results of the energy consumption equation show that income, investment, population and manufacture export positively affect the energy consumption while manufacture import negatively affect the energy consumption.

Pakistan need to implement a wide range of environmental policies that would induce industries to adopt new technologies, which could help reduce the environmental pollution. The country also need to give adequate boost to energy related research and development for the diffusion of cleaner technologies in the long-run. Some of the environmental damage in the form of pollution and economic growth is caused by various policy distortions such as protection of industry, energy subsidies, etc. environmental damage can be reduced by applying property rights over natural resources and eliminating any policy distortions. Pakistan produces those outputs which causes higher emissions, hence Pakistan need to emphasize on exporting those products which with low level of emission. To redirect the financial sector to improve environment through issuing loans to environment friendly investment ventures which not only increases the efficiency of all sectors but also improves the quality of life by saving the environment from degradation.

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