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Environmental Kuznets Curve and Pakistan: An Empirical Analysis

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Abstract

In this study, the Environmental Kuznets Curve (EKC) is hypothesized to investigate the relationship between CO_2 emission, economic growth, energy consumption, trade liberalization and population density in Pakistan with yearly data from 1971 to 2008. The cointegration analysis using Auto Regressive Distributed Lag (ARDL) bounds testing approach is incorporated. The results support the hypothesis both in short-run and long-run and inverted U-shaped relationship is found between CO_2 emission and growth. Interestingly we found trade support the environment positively and population contributes to environmental degradation in Pakistan. The energy consumption and growth are the major explanatory variables which contribute to environmental pollution in Pakistan. Moreover, the time series data analysis is used and the stability of variables in estimated model is also assessed.

Keywords: Environmental Kuznets Curve (EKC), CO_2 emission, Energy consumption, Economic Growth, Cointegration

1. Introduction:

The world wide environmental concerns due to adverse climate change impacts over planet earth have tended world economies towards the usage of green energy along with considerable reduction in CO_2 emission. According to the recent studies the large part of carbon emission will be coming from the developing

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economies due to rapid economic growth. The globalization, where it advantages the developing economies to nurture their economies through reduced investment and trade barriers and opening of technology transfer and mobilized capital and labor, it also transfers the burden of increasing share of pollution due to increase in energy consumption. Now the situation arrived where neither the environmental degradation nor the economic growth can be compromised. However, turning the simple economic growth to environmental friendly growth is a way forward. In this regard Environmental Kuznets Curve (EKC) is a hypothesized relationship between several indicators of environmental degradation and growth.

Initially the EKC was an inverted U shaped relationship between income and income inequality proposed by Simon Kuznets in 1955. The environmental Kuznets curve is adopted in environmental economic literature since 1990's, the prominant researchers such as, Grossman and Krueger (1991, 1995), Shafik and Bandyopadhay (1992), Lucas et al (1992), Panayotou (1993, 1997), Selden and Song (1994), Vincent (1996) found an inverted U-shape relationship between income and pollution for various pollutants. For two decades the EKC has been hypothesized in empirical studies and various statistical tests have been used on panel and time series data techniques related to group of countries, as a single country and cross country data as well. However, it is claimed that in order to acquire the better findings and implications single country analysis is more suitable option as countries differ in size, location and other economic characteristics. It is also suggested that EKC shows pollution and other variables of environmental degradation relationship with time so the EKC is a long run phenomenon (Lindmark 2002). As a result the time series data technique is advantageous over other techniques (Akbostanci 2008). In this study we have hypothesize the EKC for Energy consumption, Trade, Economic Growth and Population Growth. This type of empirical study is incorporated first time with four major environmental degradation variables.

The economy of pakistan has shown enormous growth during 2001 to 2007 consequently the energy consumption especially in industrial sector has added pollution to the environment. Most of the CO_2 emission is generated by natural Gas which is almost the half of the total emission. Country's better economic condition transfers the fruit to masses in shape of rise in income level which further deteriorate the environmental pollution. the transportation sector grow rapidly with simultaneous increase the number of individual and commercial vehicles. As per the statistics the per capita energy use has increased (40%) from 2001 to 2007, where the total energy used by industrial and manufacturing sector has increased (43%) during the (2008-2009). Unfortunately during this entire scenario the inefficient and under developed technology divided the environmental pollution in shape of green house gas emission. Higher demand and lack of technology fuelled up the environmental degradation. Though environment is a global issue so, the participation of every single country is valuable. Being a developing country, Government of Pakistan has taken remedial action towards the sustainable development, as a part Pakistan is also one of those countries which announce the National environmental policy NEP in 2005. The basic purpose of this initiative is to safeguard the natural environment and ensure healthy atmosphere to the citizens. The growing economy in all sectors especially industrial, increase in energy consumption. This study is undertaken in order to comprehensively test the hypothesis of Environmental Kuznets Curve for both long run and short run in presence of energy consumption, trade openness, economic growth and more especially population growth rate.

2. Literature Review

The work on environmental Kuznets curve started in 1990’s when the world started to realize that earth average temperature increased dramatically and in the same period the Earth summit in Reo-de-Janeiro, Brazil was held to discuss the Global issue of climate change . In the same period researchers of environmental economics hypothesized Environmental Kuznets curve which got alarming attention rapidly. At the time it is found that the industrialization has cause economies to emit greenhouse gases especially CO2, therefore the

first relationship was made between economic growth and CO2 emission. The work was first started by the Grossman and Krueger 1991 to study the effect on NAFTA but, EKC got more attention and importance when Shafik and Bandyopadhyay's (1992) contribute in the background study for the 1992 World Development Report stating the environmental quality improvement is essential for the sustainable development. Further this study was followed by Shukla and Parikh (1992); Grossman and Krueger (1995); Shafik (1994); Selden and Song (1995); Jaeger et al. (1995); Tucker (1995); Jha (1996); Horvath (1997); Barbier (1997); Matyas et al. (1998); Ansuategi et al. (1998); Heil and Selden (1999); List and Gallet (1999); Brandoford et al. (2000); Stern and Common (2001); Roca (2003); Friedl and Getzner (2003), Dinda and Coondoo (2006); Managi and Jena (2008); Coondoo and Dinda (2008), jalil and Mahmud (2009) and Akbostanci et al. (2009).

The economic growth engaged several industries and firms and it tends to increase the demand for energy consumption, subsequently energy consumption was also included in the hypothesis of environmental Kuznets curve. The energy consumption contribute highest to the environmental degradation, therefore the energy-economic growth nexus is included as the important determinant of carbon emission. Some of the studies in this regard include Hwang and Gum (1991); Stern (1993; 2000); Masih and Masih (1996); Yang (2000); Glasure (2002); Hondroyiannis et al. (2002); Ghali and El- Sakka (2004); Wolde-Rufael (2006, 2009); Narayan and Singh (2007); Narayan et al. (2008), and Jalil and Mahmud (2009).

After determining the energy and economic growth the trade openness is considered to be the next critical contributor to the environmental degradation. The relationship between environment and international trade has been empirically investigated but this effect depends mainly on the policies implemented within the economy. On trade determinant of environmental degradation there are two types of studies, one is for and other is against. The studies which shown trade openness influence negatively include; Suri and Chapman (1998); Schmalensee et al (1998); Beghin et al (1999); Abler et al (1999); Lopez (1994); Cole et al (2000) and Antweiler et al., (2001); Copeland and Taylor (2001); Chaudhuri and Pfaff, (2002); Ozturk and Acaravci (2010) Nasir and Rehman (2011) but it is also believed that trade openness also help to counter the negative effect in helping the economy seek technology to attain the efficiency and after certain level of growth the environmental degradation is also decline and trade play vital role. Therefore, the mix results are found in literature regarding the role of international trade. The studies whose results favor environment because of trade openness are Lucas et al. (1992); Shafik and Bandyopadhyay (1992); Birdsall and Wheeler (1993); Runge (1994); Helpman (1998); Ferrantino (1997), and Grether et al. (2007.

The other variables which are also considered beside economic growth, energy consumption and trade openness are technological movement and population growth and density. The studies which include population as the determinant of environmental degradation is Dina (2004), Shahbaz (2011) and prior to this Panayotou (1997) indicated population is one the factor contributing to the environmental degradation. The role of the economic growth rate and population density is also an essential factor. Booming economic growth and increasing population do increase moderately the environmental price. Therefore in our study we have included the population with three other major factors of environmental degradation in order to sketch the comprehensive view of economy

3. Data and Model Specification

The data is taken from the World Bank Development Indicators (WDI) from 1971 to 2008. In this section we will focus on the theoretical linkage between environmental Kuznets curve hypothesis and determinants of energy consumption, economic growth, and trade openness and population growth. According to the hypothesis as the income level increases initially it leads to poor environmental condition as economic

activity is multiplied the more pollution and dirt is spread in atmosphere and ground but as soon as the income level and growth reaches up to certain level the environment starts getting better. First the population ignores the pollution and dirt but after attaining g the high income level environment pollution bother them. For example currently some cities in developing countries may not be as clean as in developed countries' cities but after certain level of economic growth the residents will demand and care for cleanliness. Just like the cities like Mumbai-India, Saint Palo-Brazil and Shanghai-China may not be as clean as New York, Tokyo or Berlin but after shifting from the transition economy the environment of the cities will be cleaner. This trend in public and economy is considered as the inverted U shape relationship called Environmental Kuznets Curve hypothesis.

After developing the relationship between carbon emission and economic activities like growth, energy consumption and international trade, it has been studied that there is a casualty between these determinants and emission, it may be in same direction and may be in different ways and means. The different studies have been made on different individual countries but results are different because of the difference in economic characteristics and policies in each country. However many believed that the foster in economic activities enhance the energy demand which further deteriorate the environment
Yu and Jin (1992); Aqeel et al (2001); Jobert and Karanfil (2007), and Soytas et al (2009). In some studies the population and trade has been taken as the constant variables Antweiler et al. (2001). But as we mentioned above the difference in policy instrument the results may vary. Now on the basis of EKC hypothesis we can form a linear quadric function which creates relationship between carbon dioxide emission and energy consumption, economic growth, trade openness and population. We will form the long run relationship between these variables in order to test the EKC hypothesis validity we will estimate as follow;

$$lnE_t = a_0 + a_1 lnY_t + a_2 (lnY_t)^2 + a_3 (lnY)^3 + a_4 lnEN_t + a_5 lnX_t + a_6 lnP_t + \varepsilon_t \qquad (1)$$

Here, E represents per capita CO2 emission, Y per capita real income, EN energy consumption per capita (metric tons), X is the trade openness ratio, P is population growth, and ε_t is a standard error term. According to the EKC hypothesis the sign of $a_1$should be positive but the sign for $a_2 and a_3$may be negative, due to increasing change in energy consumption the value of $a_4$is also expected to be positive. Whereas the trade openness and population growth are mixed because in case of developed countries the value of $a_5$and a_6 are negative most probably; and positive in case developing countries. The difference in economic structure cause this effect because the economy of developed countries mainly rely on service industry which is clean and less energy intensive while on the other hand the economies of the developing countries mainly rely on manufacturing industry which is energy intensive and lack in technology multiply this effect of carbon emission, s*ee* Grossman and Krueger (1995).

Amongst the various methods used before, the residual based approach by Engle and Granger (1987); maximum likelihood based approach by Johansen and Juselius (1990); Autoregressive Distributor Lag (ARDL) by Pesaran et al. (2001). In this study we have prefer to use ARDL approach as it is more authentic in small samples and avoids the problems of endogeneity and help to estimate the coefficients in the long run. Moreover, the assessment of both short run and long run effects of independent variable over dependant variable take place simultaneously and does not require order of integration during econometric methods such as; unit-root-test. The recent use of similar approach for different countries studies includes; jayanthakumaran et al. (2011); Saboori (2011) , Lean et al (2011).

Now, in order to examine the long-run relationship of the variables (carbon emission, energy consumption, economic growth, trade openness and population density) through ARDL bound approach to cointegration. The equation of the model is as follows;

$$\Delta lnE_t = a_0 + \sum_{k=1}^{n} a_{1k}\,\Delta lnE_{t-k} + \sum_{k=1}^{n} a_{2k}\,\Delta lnY_{t-k} + \sum_{k=1}^{n} a_{3k}\,\Delta(lnY_{t-k})^2 + \sum_{k=1}^{n} a_{4k}\,\Delta(lnY_{t-k})^3$$
$$+ \sum_{k=1}^{n} a_{5k}\,\Delta lnEN_{t-k} + \sum_{k=1}^{n} a_{6k}\,\Delta lnX_{t-k} + \sum_{k=1}^{n} a_{7k}\,\Delta lnP_{t-k} + \delta_1 lnE_{t-1} + \delta_2 lnY_{t-1} + \delta_3(lnY_{t-1})^2$$
$$+\delta_4(lnY_{t-1})^3 + \delta_5 lnEN_{t-1} + \delta_6 lnX_{t-1} + \delta_7 lnP_{t-1} + \varepsilon_t \qquad (2)$$

Now; as per the procedure of ARDL approach the Eq.(2) is tested in Ordinary Least Square (OLS) method. The null hypothesis is tested of:H_o: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7$=0 against its alternative :H_1: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7$=0to determine the relationship of no cointegration or no long-run. The F-test is conducted to determine the existence of long-run relationship amongst the variables. The critical values of F-statistics are available with lower and upper bound limit (Note: Table 2) in Pesaran and Pesaran (1997) and Pesaran (2001). If the F-Statistics is smaller than the lower critical bound (LCB) limit then the null hypothesis of cointegration cannot be rejected but if it is greater than upper critical bound (UCB) limit then the null hypothesis is rejected. The results within the bound limits are inconclusive. After that we run the model in Schawrtz-Byesian Criteria (SBC) and Akaike's Information criteria (AIC) in order to estimate the long-terrn relationship amongst the variables. Subsequently, we estimate the Error Correction Model (ECM), the equation (3) is formulated as follow;

$$\Delta lnE_t = a_0 + \sum_{k=1}^{n} a_{1k}\,\Delta lnE_{t-k} + \sum_{k=1}^{n} a_{2k}\,\Delta lnY_{t-k} + \sum_{k=1}^{n} a_{3k}\,\Delta(lnY_{t-k})^2 + \sum_{k=1}^{n} a_{4k}\,\Delta(lnY_{t-k})^3$$
$$+ \textstyle\sum_{k=1}^{n} a_{5k}\,\Delta lnEN_{t-k} + \sum_{k=1}^{n} a_{6k}\,\Delta lnX_{t-k} + \sum_{k=1}^{n} a_{7k}\,\Delta lnP_{t-k} + \theta ECT_{t-1} + \varepsilon_t \qquad (3)$$

Here; (ECT_{t-1}) is the error correction term, and in the end we estimate the stability of coefficients through cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ).

4. Empirical Results and Interpretation

The first necessary step we follow is to investigate the the unit roots in variables through augmented Dickey–Fuller (ADF) and Philips–Perron (PP) initiated by Dickey and Fuller (1979) and Philips and Perron (1988). It helps to identify the order of variables' integration. As below Table.1 shows our variable are stationary at first difference and ready for bounds test for cointigration. Then we undertake the F-test using optimum number of lags from Vector Auto Regression (VAR). When F- statistics is obtained which is higher than the upper and lower bound limits confirm the cointegration (see Table 2). The short-run results are stated in Table.3 which shows there is no short-run relationship amongst variables except energy consumption which shows positive value but it is slightly affected.

When we turn to Table.4 for long-term relationship the positive sign on Y and negative on Y^2 shows the inverted U-shaped relationship between growth and carbon emission. Although population has smallest value but it does influence the environmental degradation in Pakistan. As the model is linear presented in log-linear form so the value of Y 6.75 denotes that the increase in 1% real GDP will raise the 6.75% per capita carbon emission. The other variables can also be calculated in same manner. The influence of energy consumption is larger than trade openness because of the economy highly rely on services and agriculture share rather than manufacturing sector. It tends to emit less carbon consequently contribute less to environmental degradation.

Now as far as error correction is concerned, it is noted that deviation from equilibrium is mainly corrected by

the energy consumption, trade, and emission but growth observed less exogenous. It shows all variable except population rely on growth. The most fruitful result of this study is turned out in shape of population, which positively influences the country's environment.

In order to check the stability amongst co-efficient the technique of Cumulative Sum (CUSUM) and Cumulative Square Sum (CUSUMSQ) technique is used (*see.* Fig.1 and Fig.2). in plot the two straight lines representing two statistics bound by the 5% significant level authenticate the stability of model as they lie within the boundaries of lines.

Fig.1

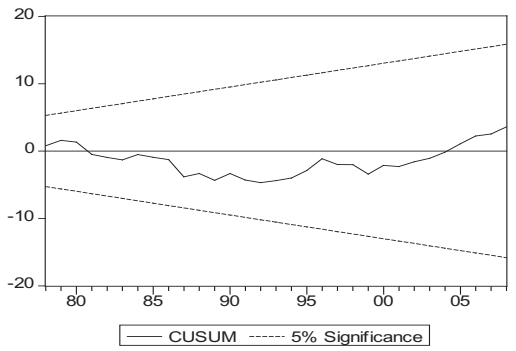
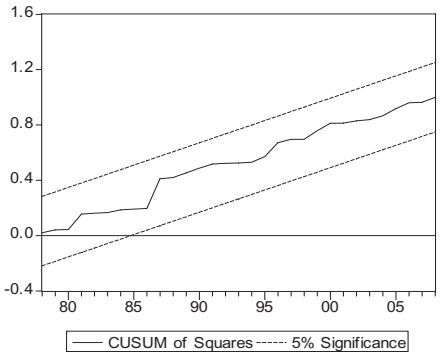


Fig.2



5. Conclusion

This study investigates the EKC hypothesis and concluded the relationship between carbon emission and other four variables (energy consumption, economic growth, trade openness and population) at the same time by using Auto Regressive Distributed Lag (ARDL) methodology for country Pakistan from the period of 1971 to 2008 through time series data analysis. The estimation was based on both short and long-run results and in the end the stability of model is also checked.

The results reveal that the short-run existence of EKC could not find but the long-run inverted U shaped hypothesis is confirmed between carbon emission and growth, energy consumption, trade openness and population density. So it is confirmed that EKC is a long-run phenomena in term of Pakistan and most interestingly with all other explanatory variable population density is also contributor to environmental degradation in Pakistan. The trade openness helps to improve the environment both in short-run path only. The error correction value also shows the quick diversion to equilibrium at long-run path. These results significantly own potential to help policy makers in Pakistan to add more efforts to implement national environmental program started back in 2005. The control on population growth is also a factor to be control, which is stagnant since 2005 after continue decline since 1990. Besides national level, there is immense need of formulating regional policies to curb the carbon emission. The carbon tariff can also be considered in worst case scenario.

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Appendix

Table 1. Unit Root Tests Result

Variable	ADF test Statistics		PP test statistics	
	Constact	Constant and Trend	Constatnt	Constant and Trend
lnE	-6.098802*	-5.925494*	-11.17908*	-10.71904*
lnY	-7.3781*	-7.350643*	-5.190726*	-5.081491*
lnEN	-4.222188*	-4.098763*	-5.371414*	-5.178689*
lnX	-2.926722**	-4.560419	-5.164466	-4.945526
lnP	-5.326813*	-4.211966	0.157161	-2.089497
lnY2	-6.496915*	-6.322685*	-4.931949*	-4.866817*
lnY3	-5.579645*	-5.410592*	-4.638653*	-4.663459*
Δlne	-6.865249	-6.382855	-6.287725	-6.441025
ΔlnY	-4.614846	-4.541309	-4.874481	-4.874361
ΔlnEN	-4.440726	-4.258443	-5.261179	-5.054259
ΔlnX	-5.007402	-4.821987	-6.123043	-6.31247
ΔlnP	-5.400854	-7.152204	-2.097497	-2.289268
Δlny2	-4.378117	-4.350362	-4.645355	-4.725334
ΔlnY3	-4.060267	-4.116628	-4.392642	-4.585298

Note: *, ** Indicates rejection of null hypothesis at 1%, 10% of significance level with first difference respectively

Table 2.F-test Results for Cointegration

F-statistics	Optimum lag order	Lower Bound	Upper Bound
10.70905*	1,1,1,0,1	I(0)	I(1)

*Significant at 1% level

Note: CV [at 1% (3.516, 4.781), 5% (2.649, 3.805) and 10% (2.262, 3.367)] by Pesaran (et al 2001)

Table 3.The Result of Error correction Model

Regressor	Coefficient	t-Statistics
Δ lnY	7.98	0.83
Δ lnY^2	4.12	0.37
Δ lnY^3	0.92	0.097
Δ lnEN	0.048	0.057
Δ lnX	0.02	0.11
Δ lnP	-2.311	-3.643***
Δ lnC	0.05	3.01***

ECT(-1)	-0.5				-3.2**
Diagnostic Test Statistics					
R Squared	0.782606	lnY	-0.866	lnX	-0.168
F (7,27)	6.138	lnY^2	-2.49	lnP	-1.724
DW Statistics	1.475	lnY^3	-5.19		
RSS	0.189	lnEN	0.0131		

Note: ** and *** indicates coefficient significance at 5% and 10% of significance level

Table 4.Longrun estimate results and diagnostic test stats

Dependant Variable: lnE		
Regressor	Coefficient	t-values
lnY	6.75	2.83***
lnY^2	-0.49	-2.48**
lnY^3	-5.69	-7.08*
lnEN	1.272	2.334***
lnX	0.109	2.431***
lnP	0.081	0.948***
lnC	8.426	2.538***
Diagnostic test statistics	Teat-Stats	p-value
Serial corelation	0.1399	0.74
Functional form	0.553	0.29
Normality	0.71	0.401
Heteroskedasticity	0.63	0.37

Note: *, ** and *** indicates the significance of coefficient at 1%, 5%, and 10% significance level respectively