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DOES ECONOMIC EXPANSION COSTS ENVIRONMENTAL DEGRADATION? TESTING KUZNET'S INVERSE U SHAPED CURVE IN PAKISTAN COUNTRY

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ABSTRACT

This research investigates whether economic expansion costs environmental degradation by testing environmental Kuznets' inverse U shaped curve hypothesis in developing country like Pakistan. The time series data from 1960 to 2017 for the study variables (i.e. Industrialization, Urbanization, International Trade, Energy Consumption, Squared GDP and CO2 emission) has been extracted from WDI (i.e. World Development Indicators). The Co integration and VECM dynamic systems have been applied to investigate long and short run effect of predictors on environmental degradation. We conclude that industrialization and energy consumption positively and significantly contribute in deteriorating the environment in Pakistan. On the other hand, International trade has no effect on environmental degradation. This may be because Pakistan imports more than it exports. Moreover, Pakistan largely exports raw materials and agriculture products. Therefore, Pakistan requires less harmful industrial productions or CO2 emissions; hence, less damage to environmental conditions. On the other hand, urbanization significantly and negatively affects CO2 emissions. Finally, the coefficient of GDP2 suggests significant and negative effect on environmental degradation and indicates that the environmental degradation starts decreasing significantly. The results of our research are consistent with the Environmental

Kuznets Curve (EKC), which states that at the initial stage, country's income increases at the expense of environmental degradation.

INTRODUCTION

The Environmental Deterioration is considered as one of the biggest threat in the world today and significant attention has been paid to it in literature (Sarkodie & Strezov, 2018). The planet is being polluted because of adverse effect of this climate change. Consequently, world players are taking specific measures to reduce carbon dioxide CO2 emission by promoting the use of green energy sources (Ahmed & Long, 2012). The history of the earth and the climatic observations has shown that the climate varies according to the eras and locations for millennia, alternating between ice ages and warmer ones. These changes are generally spread over long periods averaging 100,000 years and 10,000 respectively. Nevertheless, in recent decades, climate change seems to be intensified, prompting the public to question the causes of these upheavals and their short and long-run consequences on lifestyles, health, ecosystem and the economy as a whole.

Ozturk and Acaravci (2010) argued that amongst all greenhouse gases affecting environment, CO2 is contributing more than 60 percent to environmental degradation along with contributing to economic growth at the same time. As environment pollutes, it directly contaminates air and drinking water resulting in adverse effect on ecosystem. When dynamics of climate changes, it disturbs overall natural mechanism needed to provide human and other beings with hygienic food they eat and clean air they breathe. Ultimately, it adversely affects the society in terms of health, poverty, living conditions, hunger and population etc.(Watson & Albritton, 2001). In reality, Co2 emissions resulted from industrial or other likewise contaminating processes, directly affect living beings of the planet earth. Accordingly, Pope and Dockery (2006) argued that it is putting human lives at stake in the shape of different diseases such as cancer, heart and other inflammations.

There are numerous models have been tested to investigate the relationship between different economic indicators and economic growth. However, the Environmental Kuznets Curve (EKC) hypothesis provides systematic foundation for environmental degradation and economic growth. The Kuznets Curve hypothesizes that at the initial phase of economic development, the country starts industrial processes on large scale along with technological inclusion which leads to escalation in environmental degradation (Panayotou, 1993; Sarkodie & Strezov, 2018a). However, as the initial stage ends, country experiences a significant rise in per capita income or GDP along with institutional quality, awareness about environmental issues increases. As a result, environmental degradation decreases because the overall benefits of the economic growth are shared with the entire society.

Keeping in view the global concerns over improving environmental conditions for the good of the planet earth and its living beings, this study has tried to explore factors which contribute more towards environmental degradation in Pakistan.

Moreover, the Environmental Kuznets Curve (EKC) with inverse U shaped hypothesis will be tested to examine whether or not it can be validated in Pakistan.

Problem Statement

Environmental Degradation poses a massive problem to the entire planet earth and creatures. As noxious waste gather in the environment the effect of greenhouse gases leads to global warming. Consequently, temperature hikes globally and frozen ice thaws out more quickly resulting sea level to increase (McMichael, Woodruff & Hales, 2006). An increased famine is another unnecessary result of global warming, which makes it difficult to survive for the people and other beings living in areas near equator (Dai, 2013). One reason to the environmental degradation, often emphasized, is an economic expansion. Moreover, with the growing economies through industrial production, global warming has drawn an attention from state owners, United Nations, business individuals and industrialists, research practitioners etc. universally to raise the voice and work vigorously on sources of economic expansion costing environmental degradation. The idea is based on assumption that greater the production of goods and service in the economy, larger will be the environmental degradation. Nevertheless, few practitioners assume that correlation between economic expansion and environmental degradation is not as simple as discussed in literature. On the one hand, most studies suggested that economic expansion costs environmental degradation (Azlina, 2012; Alam, Begum, Buysse & Van Huylenbroeck, 2012; Chang & Carballo, 2011; Hwang & Yoo, 2014; Pao & Tsai, 2011; Saboori & Soleymani, 2011; Shaari, Hussain & Ismail, 2012). On the other hand, Dinda (2004) argued that environment improves with economic expansion.

The problem of environmental degradation is not merely a moral responsibility, but it is also the matter of survival of human and other beings breathing on the planet earth. In the globe where economic expansion cannot be avoided and production has to be increased continuously to meet the growing needs, it is the responsibility of researchers to discover the key reasons of environmental degradation and to offer unique solutions thereof.

This study has explored factors which contribute most to the environmental degradation. Furthermore, this study has provided opinion on whether or not economic expansion costs environmental degradation in Pakistan i.e. the core objective of the research. In order to validate this, Kuznet's inverse U shaped Curve hypothesis of Simon Kuznets (i.e. originally developed for income inequality and economic growth) will be tested.

Research Hypotheses

Following are the research hypothesis to be tested in this research paper:

a) There is a significant effect of Industrialization on environmental degradation

b) There is a significant effect of Urbanization on environmental degradation

c) There is a significant effect of on International Trade environmental degradation

d) There is a significant effect of Energy Consumption on environmental degradation

e) There is a significant effect of squared GDP on environmental degradation

Review of Literature

Today, climate change and environmental degradation is one of the major challenges faced by the entire planet. The studies on climate change demonstrate that global warming is now a reality and should be dealt seriously in order to make this universe free to live. There is always a limit for everything to absorb. When polluted waste disperse in the environment beyond the limit, contaminated waste gather in the environment which leads to environmental degradation (Bhattacharyya, 2011).

The empirical and/or scientific research have revealed that global temperature has been steadily increasing since 1870, recording an average annual growth rate of 0.8 °C. Moreover, the last decade has been the hottest ever recorded, resulting in many climatic disturbances, such as floods, droughts, desertification etc. Natural factors alone cannot explain the magnitude and speed of current climate change. The 22nd Conference held in Morocco in 2016 witnessed numerous new initiatives in this direction, including support measures for clean technologies, capacity building to report on climate action plans, and initiatives to address climate change to enhance food security and water supply in developing countries. Nevertheless, these efforts remain modest in relation to the remaining room to maneuver and are likely to be insufficient in the absence of concrete action at the global level, and more particularly countries with high carbon dioxide (CO_2) emissions.

Globally, there are numerous associations and inter-country alliances working together to mitigate the effect of environmental degradation. IPPC (2014) reported that in 2010, the emissions from greenhouse gases in Asia grew by almost 330%, 22% in OECD countries 57% in Latin America and 70% in Africa and Middle East.

The world economic growth mostly hinges on fossil fuels therefore CO_2 emissions have direct impact on the sustainability of the planet earth. The problems such as greenhouse effects, and climate change are mostly the result of CO_2 emissions. Consequently, most of the researchers in their studies have focused on CO_2

emissions and its effects on economic growth (Musolesi A, Mazzanti M. Nonlinearity, 2013; Yang J, Cheng B, 2014).

The factors which affect greenhouse gas emission may include population growth, per capita production, technology, energy consumption, adoption of infrastructure method, innovation etc. Blanco, Gerlagh, Suh, Barrett, deConinck, DiazMorejon, Mathur, Nakicenovic, Ahenkorah, Pan, Pathak, Rice, Richels, Smith, Stern, Toth and Zhou (2014) argued that CO2 emissions from fossil fuel use, burning and manufacturing procedures added about 78 percent of total emissions in the period 2000-2010. This has led countries to depend more on fossil fuel energy sources as it is more affordable and cheaper than other sources (Sarkodie & Owusu, 2016). The association between energy consumption and economic growth is bit difficult to judge overtime, but the availability of the energy is imperative to accelerate country's economy (United Nations, 2015).

In fact, according to the effect of scale production, an increase in the gross domestic product (GDP) corresponds to an increase in pollution levels. However, long-term GDP growth would mitigate the effect of scale production by moving the economy towards productive activities with a marginal intensity of minor pollution, such as the tertiary sector. According to Luzzati & Orsini (2009), the multidimensional nature of environmental damage represents a serious methodological limitation. There is also variability in their emission model (monotonic, inverse, increasing, decreasing, etc.). Empirical studies have adopted a curve of energy-environmental Kuznets, using energy consumption as an indicator of environmental damage.

The energy efficiency is low in developing countries and is deteriorating environment due to higher production of export goods. On the other hand, developed countries have improved energy efficiency because they import goods rather than produce at home to reduce environmental damage. Consequently, these findings provide a base for the importance of carbon leakage, which already quantified in some studies (Eichner and Pethig 2011). The sources which drive economic growth such as technological boom may significantly impact climate change (Sarkodie, 2018). Therefore, as compared to developed economies, the economic growth of underdeveloped countries is likely to be carbon intensive owing to innovation and technological shift.

Key question of this study is as follows:

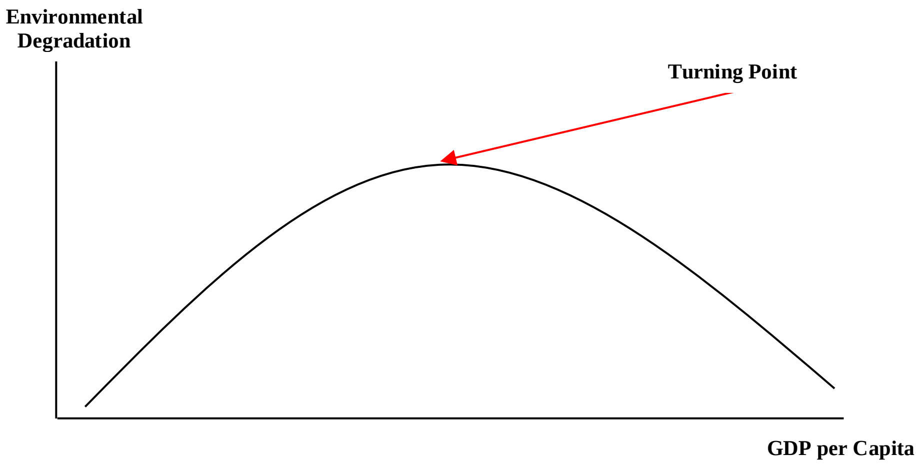
Does economic expansion costs environmental degradation? The drivers of the economic growth or expansion for this study include industrialization, squared GDP, Urbanization, Energy Consumption, and International Trade. Different theories of Kuznets Curve are discussed in the following section to answer the study question.

Theoretical Evidence

Mainly, there are three key theories to explain the association between economic expansion and environmental degradation which are discussed as under.

The Environmental Kuznets Curve (EKC)

Originally, Environmental Kuznets Curve was framed to describe the inverse U shaped relationship between economic growth and income inequality by Simon Kuznet. He argued that as income of the country increases, income inequality also increases. However, later with the growth in income, inequality started to decline as benefits of economic growth are shared with the entire society (Kuznets, 1955). However, in 1990's the Kuznet's curve was adopted in environmental economics theories and became Environmental Kuznet's Curve. This concept was tied with environment deterioration to describe its relation with economic growth (Grossman & Krueger, 1995). According to the environmental Kuznets hypothesis, in early stage of development countries usually use low greenhouse gas emissions.

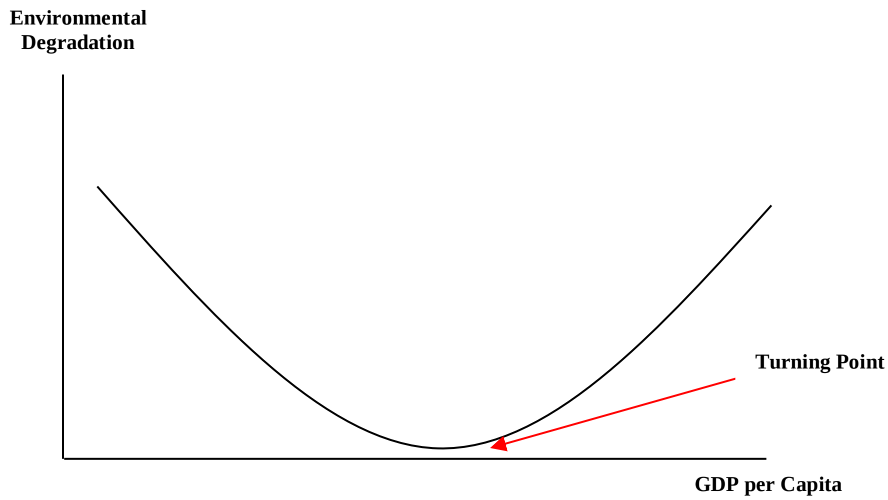


In the development process, as they add value to the economy, the countries often move towards emission-intensive industrial productions and then service sector improvements. Ultimately, after reaching a certain level of economic growth, the countries adapt modern technologies for production processes and energy efficiency. Therefore, environment gets a greater importance, which eventually leads to decline in overall emissions or environmental degradation.

The eminent research practitioners found association between economic growth and environmental degradation as inverse U shape for several pollutants such as CO_2, and other poisons (Lucas, Wheeler & Hettige, 1992; Shafik & Bandyopadhay, 1992; Panayotou, 1993; Selden & Song, 1994; Vincent, 1996). Put differently, at the initial phase when economy moves towards increasing trend, the environment gets polluted significantly till the economy researches a peek or turning point. Later, the environment improves because countries invest in technology to reduce environmental degradation (Sharma, 2011; Sulemana, James & Rikoon, 2017; Antonakakisa, Chatziantoniou & Filis, 2017).

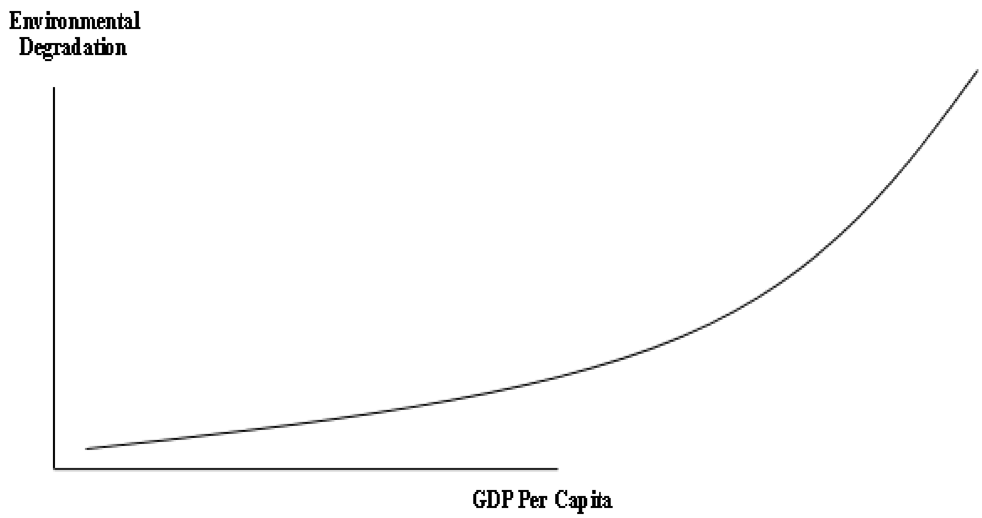
Brundtland Curve Hypothesis

The above hypothesis suggests that environment get worsen in poor countries initially and with the economic growth, the environment quality improves. However, after reaching the turning point or lower point, the environmental degradation started to rise again therefore, Brundtland curve as opposed to EKC is U shaped as illustrated in the following figure.



Environmental Daly curve hypothesis.

The **Daly curve hypothesis** suggests that there always increase in environmental deterioration with the rise in GDP per capita owing to continuous increase in production of goods. Bratt (2012) argued that there is no turning point in Daly curve as compared to both EKC and Brundtland curve as illustrated in the following figure.



For many years, Environmental Kuznets Curve is being hypothesized in research and several econometric techniques are applied on time series data (i.e. for *i*=1 and *t=1,2, 3,.n*), panel data (for *i=1, 2, 3….n* and *t=1,2, 3, ….n*) and cross sectional data (*i=1, 2, 3….n* and *t=1*). However, various countries differ in economic indicators, size, location etc. Ozcan (2013) used panel data of 12 Middle Eastern economies for validating the EKC hypothesis. His study found both inverted U shaped curve and U shaped curves for merely 3 and 5 countries respectively. Similarly, using the panel data, Yang, He, and Chen (2015) found Environmental Kuznets hypothesis as invalid because of less than 95% likelihood of getting negative coefficient of the income or GDP.

Tutulmaz (2015) used time series data for the period of 40 years in case of Turkey. He argued that estimation of the EKC model must be conducted without restriction because restriction in co-integration equation may be a main cause of diversion of EKC in case sensitivity exists. The researchers suggested that time series analysis is more appropriate to get robust results and its implications. Keeping this in view the same, this study is based on time series data for Pakistan only for 50 years to investigate whether or not EKC fits into the data.

Data and Model Specifications

This chapter explains data series and econometric model along with variables included to investigate the long run and short run effects of economic growth variables such as Industrialization, Urbanization, International Trade, Energy Consumption and Squared GDP on environmental degradation (i.e. CO2 emission). The data for these variables have been extracted from World Development Indicators (WDI) for the period of 58 years from 1960 to 2017.This research has estimated environmental degradation and economic expansion nexus by adopting models used by Soytas, Sari, and Ewing (2007); Shahbaz, Lean and Shabbir

(2010c) Halicioglu (2009); Ang, 2008); Jalil and Mehmud (2009). The aforementioned studies used single equation modeling to estimate nexus between energy-growth, and emission-growth. Nevertheless, this paper included urbanization and industrialization because both can also be the cause of emission. The assumption behind using these variables is that: in Pakistan, it is observed that people are continuously moving from rural areas to urban areas since long for livelihood and they mostly work in industries. As a result, annual growth in urbanization and industrial production has significantly increased which has led increase in CO2 emission. In the following mathematical equation, this research suggested that CO2 is the function of Industrialization, Urbanization, International Trade, Energy Consumption and Squared GDP.

$$CO_2 = f\left(Ind, Urb, IntTrd, EC, GDP^2\right) \quad \textbf{(1)}$$

The mathematical equation is converted to statistical equation in order to estimate its coefficients as follows:

$$CO_2 = \beta_0 + \beta_1 Ind + \beta_2 Urb + \beta_3 IntTrd + \beta_4 EC + \beta_5 GDP^2 + \mu \quad \textbf{(2)}$$

Where CO_2 is the dependent variable and is peroxided by CO2 emissions in kg per 2010 USD of GDP. *Ind* denotes industrialization and is peroxided by manufacturing value added in constant 2010 USD. The rationale behind using this proxy is that Katz (2016) measured the industrialization by using proxy such as total investment in production and total production output value (both per capita). As manufacturing value added is very close to both aforementioned variables, therefore, it is used in this paper.*Urb* denotes Urbanization and proxy used for this is annual growth in urban population in percentage. *IntTrd* denotes International Trade and is measured as the difference between export and import of goods and services in constant 2010 UDS.*EC* denotes Energy Use in kg of oil equivalent per capita and finally GDP^2 is the square of GDP per capita constant 2010 USD. Moreover, $B_0, B_1, B_2, B_3, B_4,$and B_5 are coefficients of the model and μ is the error term or residual (also known as disturbance).

Estimation Strategy

Because time series data is used in this paper for 58 year, therefore, ADF unit root test will be applied to remove the shocks. If the variables integrated at first difference *I(1)*, then Johansen Co integration test will be applied to check long run association between CO2 emission and predictors (Johansen & Juselius, 1990). Moreover, short run association for the same will be tested by applying Error Correction Model (ECM).

Results and Interpretations

This chapter will explain the results generated through EVIEWS to justify the results that whether these are consistent with Environmental Kuznets Curve hypothesis or not. Time series analysis will be conducted in the following section.

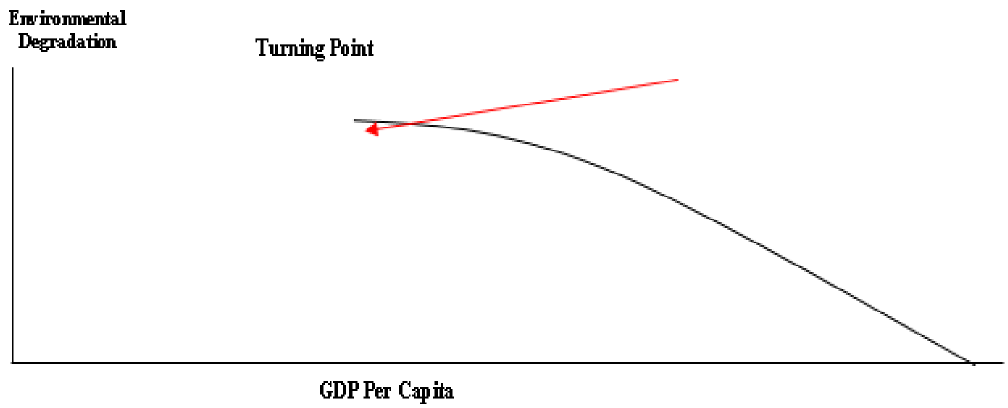
Table 4.1: Ordinary Least Square

Variable	Coefficient	Std. Error	t-Statistic	Prob.
IND	4.26E-11	1.64E-11	2.597160	0.0122
URB	-0.353559	0.054709	-6.462479	0.0000
IT	-5.37E-12	6.93E-12	-0.775794	0.4414
EC	0.000760	0.000126	6.053823	0.0000
SQUARED_GDP	-1.92E-06	3.99E-07	-4.819485	0.0000
C	2.433378	0.223585	10.88345	0.0000
R-squared	0.687706	Mean dependent var		0.818008
Adjusted R-squared	0.657677	S.D. dependent var		0.222023
S.E. of regression	0.129902	Akaike info criterion		-1.146375
Sum squared resid	0.877476	Schwarz criterion		-0.933226
Log likelihood	39.24487	Hannan-Quinn criter.		-1.063349
F-statistic	22.90192	Durbin-Watson stat		0.485878
Prob(F-statistic)	0.000000			

In the above **Table 4.1** Ordinary Least Square (OLS) results are demonstrated. According to the above results, independent variables such as IND (i.e. Industrialization) and EC (i.e. energy consumptions) have positive and significant effect on CO2 emission (i.e. Environmental Degradation. Furthermore, one-unit increase in Industrialization and Energy Consumption lead to increase in CO2 emission by 0.0000000000426 and 0.000760 respectively. Thus, we can say that as industrialization and energy consumption increase, it leads to deteriorate environmental condition in Pakistan. Furthermore, IT (i.e. International Trade) which is measured as export minus import shows insignificant or no effect on CO2 emission. We can justify these results in a way that, in a country where imports are higher than exports (as in case of Pakistan) production of goods is less because to meet there demand they import goods from other countries. As a result, there have little or no CO2 emissions and no effect on environmental deterioration.

In addition, the independent variable URB (i.e. Urbanization) has significant but negative effect on CO2 emissions. Meaning that, as people move from rural areas to urban areas, it improves the environmental conditions in Pakistan.

Finally, independent variables SQUARED_GDP (i.e. GDP^2) showed significant and negative effect on CO2 emissions. Therefore, we can conclude that when GDP per capital reached the turning point, the environmental degradation started to decrease significantly, as shown in the following figure. Put differently, we can say that as soon as income of the country reaches the threshold level, the country starts investing in environmental improvements by implementing rules and regulations for industrial processes to protect the society from environmental damages. These results of our research are consistent with the Environmental Kuznets Curve (EKC), which states that at the initial stage, country's income increases at the expense of environmental degradation. However, at the later stage when income or GDP squared or reach the turning point, the environment gets improve, because benefits of the country's income are shared with the overall society as illustrated in the following figure. Also, our results are consistent with previous researches conducted by (Azlina, 2012; Alam, Begum, Buysse & Van Huylenbroeck, 2012; Chang& Carballo, 2011; Hwang & Yoo, 2014; Pao & Tsai, 2011; Saboori & Soleymani, 2011; Shaari, Hussain & Ismail, 2012).



The R-Squared value of 0.687706 in the above *table 4.1* suggests the goodness of the fit model. It suggests that 68.77% in the dependent variables CO2 emission is explained by all predictors included in the model. Thus, our model is moderately strong and fit for the further analysis. Also, the Prob(F-statistic) value (i.e. 0.000) proves significance of the overall model because the probability value is significant at 5% level.

SHORT RUN AND LONG RUN EFFECT OF PREDICTORS ON CO2 EMISSIONS

Before proceeding to long run co integrations, it is advised to test the stationary of the variables. For this purpose, we will apply the ADF unit root test (as suggested by majority of the researchers).

Following is the ***AR(1)*** model with a unit root:

$$Y_t = Y_{t-1} + \nabla Y_t, \qquad t = 1,2,3.....,T, \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \quad (3)$$

$$\nabla Y_t = \delta + \varepsilon_t,$$

Where:
Y_t is non-stationary and the process ΔY_t is stationary. We denote Y_t a Difference stationary process. If ΔY_t is stationary while Y_t is not, Y_t is called integrated of *first order*, *I*(1). A process is integrated of order *d*, *I*(d), if it contains *d* unit roots.

Hypothesis for ADF Test

H_0: Unit root or non stationary ($\rho = 1$)
H_A: NO unit root or is stationary ($\rho < 1$)
The results of the ADF test are given in the below table.

Table 4.2: ADF Unit Root Test

Variables	**At Level**	**At 1st Difference**	**Stationary At**
	Prob.	**Prob.**	
CO2	0.9238	0.0000	Same Order *I*(1)
IND	1.0000	0.0291	Same Order *I*(1)
URB	0.8772	0.0001	Same Order *I*(1)
IT	0.0981	0.0000	Same Order *I*(1)
EC	0.4994	0.0000	Same Order *I*(1)
SQUARED_GDP	0.9999	0.0500	Same Order *I*(1)

Table 4.2 mentioned above is the summary of ADF test. The results indicate that originally study variables were non stationary at level ***I*(0)**, because prob. values for all the variables are greater than 0.05 (i.e. Co2 = 0.9238, EC= 0.4994, IND= 1.0000, IT= 0.0981, Squared GDP= 0.9999, URB = 0.8772. Therefore, the study failed to reject null hypothesis that data is non-stationary or has unit root ($\rho = 1$).

However, time series data is required to be stationery for further analysis, therefore, in order to convert non stationery data into stationery we checked the variables by taking 1st difference. The 3rd column in the above table exhibits the results at 1st difference. The results shows that all the variables became stationary at first difference or at same order ***I*(1)** as prob. values for all variables are significant at 5% level. Thus, data is stationary or has no unit root at same order *I*(1). Now, as we know that our variables become stationery at same order ***I*(1)**, we will proceed for further analysis to check whether there exists a long relationship between CO2 Emissions (i.e. Environmental Degradation) and economic growth indicators (i.e. Industrialization, Urbanization, International Trade, Energy Consumption and Squared GDP). For this purpose, *Johansen Co-integration* technique is applied.
But, before applying co integration test, it is advised to select optimum lags to be included in the model. Following is the results for optimum lag selection criteria.

Table 4.3: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3470.712	NA	3.83e+49	131.1967	131.4197	131.2824
1	-3067.480	699.9498	3.71e+43	117.3389	118.9002*	117.9393*
2	-3020.093	71.52663	2.54e+43	116.9092	119.8089	118.0243
3	-2969.638	64.73580 *	1.69e+43 *	116.3637	120.6017	117.9934
4	-2930.484	41.36998	2.00e+43	116.2447	121.8210	118.3890
5	-2886.417	36.58404	2.51e+43	115.9403*	122.8549	118.5993

The above table 4.3 illustrates the lag order selection criteria. The results indicate that SC and HQ criterion suggest one lag. However, LR and FPE suggest 3 lags. AIC suggested 5 lags. Furthermore, two criterions suggest 1 lag and two other criterions suggest 3 lags therefore, we will go for 3 because adding more lags provide the robust results for Co integration and VECM systems as discussed in following section.

Hypothesis for Johansen Co-Integration Test

$H_0 : r = 0 \quad H_A : r = 1$

$H_0 : r = \leq 1 \quad H_A : r = 2$

$H_0 : r = \leq 2 \quad H_A : r = 3$

$H_0 : r = \leq 3 \quad H_A : r = 4$

Table 4.4: Johansen System Co integration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.603043	142.6489	95.75366	0.0000
At most 1 *	0.503414	92.75679	69.81889	0.0003
At most 2 *	0.405115	54.95689	47.85613	0.0093
At most 3	0.232007	26.90999	29.79707	0.1039
At most 4	0.204211	12.65535	15.49471	0.1281
At most 5	0.005919	0.320577	3.841466	0.5713
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.603043	49.89208	40.07757	0.0029

At most 1 *	0.503414	37.79990	33.87687	0.0161
At most 2 *	0.405115	28.04690	27.58434	0.0436
At most 3	0.232007	14.25464	21.13162	0.3445
At most 4	0.204211	12.33477	14.26460	0.0987
At most 5	0.005919	0.320577	3.841466	0.5713
Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Table 4.4 presented above shows the results of Johansen Co integration test. Both the tests criterion (i.e. Trace Statistic and Maximum Eigen Value) indicate ***at most 3*** Co integrating equation at 5% level because the prob. Values for both criteria ***at most 3*** are greater than 0.05 (i.e. Trace Statistic=0.5331 and Maximum Eigen value= 0.3943). Hence, we reject the null hypotheses and suggest at most 3 ***(three)*** Co integrating equations, which means there exists co integration among Environmental Degradation and economic growth in the long run at 3 co integrating equation.

Moreover, as we know that Co-integration between environmental degradation and economic growth exists in long run therefore, we will now apply VECM model to examine short run relationship between the same.

Conventional Error Correction Model:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \delta_i \Delta X_{t-i} + \varphi Z_{t-1} + \mu_t$$

The above ECM model states that change in Y (i.e. ΔY) or dependent variable is the function of not only change in previous changes in Y (i.e. ΔY_{t-i}) but also include past changes in X (i.e. ΔX_{t-i}) when all variables are considered endogenous. More importantly, we have specified Error Correction Term (i.e. φZ_{t-1}) which actually is variable of lagged OLS residual of following long run co integrating equation.

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t + \text{..........} + \beta_n X_t + \mu_t$$

The above lagged OLS residual can be defined as follows:

$$Z_{t-1} = ECT_{t-1} = Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$$

The above equation of ECT is actually called co integrating equation used to examine the long run association between dependent variable and predictors. The term, Error Correction, relates to the fact that last period deviation (i.e. the error) from long run equilibrium affects the short run dynamics of the dependent variable. As a result, the coefficient of the ECT (i.e. φ) is the *Speed of Adjustment*; it measures the speed at which Y returns to the equilibrium after a change in explanatory variable X.

VECM Model of this study:

$$\Delta CO2_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta CO2_{t-1} + \beta_2 \Delta CO2_{t-2} + \beta_3 \Delta CO2_{t-3} + \sum_{i=0}^{n} \begin{matrix} \delta_1 \Delta Ind_{t-1} + \delta_2 \Delta Ind_{t-2} + \delta_3 \Delta Ind_{t-3} + \delta_4 \Delta Urb_{t-1} + \delta_5 \Delta Urb_{t-2} + \delta_6 \Delta Urb_{t-3} \\ + \delta_7 \Delta IT_{t-1} + \delta_8 \Delta IT_{t-2} + \delta_9 \Delta IT_{t-3} + \delta_{10} \Delta EC_{t-1} + \delta_{11} \Delta EC_{t-2} + \delta_{12} \Delta EC_{t-3} \\ + \delta_{13} \Delta GDP^2{}_{t-1} + \delta_{14} \Delta GDP^2{}_{t-2} + \delta_{15} \Delta GDP^2{}_{t-3} + \varphi Z_{t-1} + \mu_t \end{matrix}$$

The Error Correction Term (i.e. φZ_{t-1}) of the above VECM system is variable of lagged OLS residual of long run co integrating equations for this research is as follows:

$$CO2_t = \beta_0 + \beta_1 Ind_t + \beta_2 Urb_t + \beta_3 IT_t + \beta_4 EC_t + \beta_5 X_t + \mu_t$$

For this study, the above lagged OLS residual can be explained as under:

$$Z_{t-1} = ECT_{t-1} = CO2_{t-1} - \beta_0 - \beta_1 Ind_{t-1} - \beta_2 Urb_{t-1} - \beta_3 IT_{t-1} - \beta_4 EC_{t-1} - \beta_5 GDP^2{}_{t-1}$$

Now, we will estimate the VECM equation and co integrating equations by applying Vector Error Correction in Eviews. The results of the test are given below:

Table 4.5: Vector Error Correction Model

Cointegrating Eq:	**CointEq1**	**CointEq2**	**CointEq3**			
CO2(-1)	1.000000	0.000000	0.000000			
IND(-1)	0.000000	1.000000	0.000000			
URB(-1)	0.000000	0.000000	1.000000			
IT(-1)	-1.02E-10	-2.317955	-3.93E-10			
	(2.2E-11)	(0.59595)	(1.2E-10)			
	[-4.69567]	[-3.88948]	[-3.28249]			
EC(-1)	0.001366	-2494970.	-0.004682			
	(0.00035)	(9528371)	(0.00191)			
	[3.91906]	[-0.26185]	[-2.44633]			
SQUARED_GDP(-1)	-1.07E-06	-36276.85	3.83E-07			
	(2.1E-07)	(5717.86)	(1.1E-06)			
	[-5.09187]	[-6.34448]	[0.33365]			
C	-1.749299	-1.31E+10	-6.365900			
Error Correction:	D(CO2)	D(IND)	D(URB)	D(IT)	D(EC)	D(SQUARED_GDP)
CointEq1	0.503113	-1.08E+08	-0.389210	-3.85E+09	225.5767	-62626.71
	(0.30189)	(8.4E+08)	(0.10672)	(4.6E+09)	(197.329)	(38435.2)
	[1.66654]	[-0.12876]	[-3.64692]	[-0.83546]	[1.14315]	[-1.62941]
CointEq2	-1.69E-11	0.048592	3.32E-11	0.426220	-7.34E-09	-9.65E-06
	(3.6E-11)	(0.10061)	(1.3E-11)	(0.55286)	(2.4E-08)	(4.6E-06)
	[-0.46682]	[0.48296]	[2.59654]	[0.77093]	[-0.31002]	[-2.09285]
CointEq3	0.016236	-4.55E+08	-0.111524	-4.04E+08	25.80262	51225.36
	(0.15318)	(4.3E+08)	(0.05415)	(2.3E+09)	(100.126)	(19502.2)
	[0.10599]	[-1.06812]	[-2.05947]	[-0.17268]	[0.25770]	[2.62665]
D(CO2(-1))	-0.494933	2.94E+08	0.371288	9.89E+09	-431.1020	111548.1
	(0.48544)	(1.3E+09)	(0.17161)	(7.4E+09)	(317.303)	(61803.5)
	[-1.01956]	[0.21782]	[2.16355]	[1.33489]	[-1.35864]	[1.80488]
D(CO2(-2))	-0.717567	-1.65E+09	0.174967	1.70E+09	-327.8313	15922.49

	(0.50599)	(1.4E+09)	(0.17887)	(7.7E+09)	(330.735)	(64419.5)
	[-1.41816]	[-1.17161]	[0.97816]	[0.21963]	[-0.99122]	[0.24717]
D(CO2(-3))	-0.300358	2.84E+08	-0.006571	3.77E+09	222.8242	104003.6
	(0.62369)	(1.7E+09)	(0.22048)	(9.5E+09)	(407.668)	(79404.4)
	[-0.48159]	[0.16389]	[-0.02980]	[0.39604]	[0.54658]	[1.30980]
D(IND(-1))	4.31E-13	0.103487	-7.03E-11	0.995967	3.52E-08	5.22E-05
	(1.1E-10)	(0.29253)	(3.7E-11)	(1.60746)	(6.9E-08)	(1.3E-05)
	[0.00409]	[0.35376]	[-1.88833]	[0.61959]	[0.51154]	[3.89532]
D(IND(-2))	-4.68E-11	-0.207093	-2.48E-11	1.133285	-3.92E-08	4.58E-05
	(9.7E-11)	(0.27033)	(3.4E-11)	(1.48544)	(6.4E-08)	(1.2E-05)
	[-0.48155]	[-0.76608]	[-0.72148]	[0.76293]	[-0.61683]	[3.69661]
D(IND(-3))	4.20E-11	0.009124	5.71E-12	2.953618	4.28E-08	1.61E-05
	(8.0E-11)	(0.22341)	(2.8E-11)	(1.22763)	(5.3E-08)	(1.0E-05)
	[0.52190]	[0.04084]	[0.20090]	[2.40594]	[0.81426]	[1.57307]
D(URB(-1))	0.099412	-4.03E+08	0.199900	-1.57E+10	80.54705	-16661.77
	(0.51348)	(1.4E+09)	(0.18152)	(7.8E+09)	(335.630)	(65373.1)
	[0.19361]	[-0.28269]	[1.10124]	[-2.00193]	[0.23999]	[-0.25487]
D(URB(-2))	0.014868	-61298006	-0.013014	4.66E+08	-29.27892	20693.32
	(0.21094)	(5.9E+08)	(0.07457)	(3.2E+09)	(137.881)	(26856.1)
	[0.07048]	[-0.10458]	[-0.17452]	[0.14474]	[-0.21235]	[0.77053]
D(URB(-3))	-0.043484	-29094209	0.021338	2.72E+09	-4.818888	-5883.756
	(0.18014)	(5.0E+08)	(0.06368)	(2.8E+09)	(117.747)	(22934.4)
	[-0.24139]	[-0.05812]	[0.33508]	[0.98893]	[-0.04093]	[-0.25655]
D(IT(-1))	5.09E-12	0.000894	-1.42E-11	-0.103081	2.49E-09	-2.53E-06
	(1.7E-11)	(0.04843)	(6.2E-12)	(0.26610)	(1.1E-08)	(2.2E-06)
	[0.29211]	[0.01846]	[-2.31267]	[-0.38738]	[0.21863]	[-1.14026]
D(IT(-2))	4.06E-13	-0.091728	-1.20E-12	-0.185858	1.73E-09	-3.54E-06
	(1.3E-11)	(0.03602)	(4.6E-12)	(0.19792)	(8.5E-09)	(1.7E-06)
	[0.03135]	[-2.54666]	[-0.26224]	[-0.93905]	[0.20401]	[-2.14522]
D(IT(-3))	1.07E-11	-0.018515	-2.47E-12	0.378413	1.11E-08	-4.51E-07
	(1.2E-11)	(0.03243)	(4.1E-12)	(0.17819)	(7.6E-09)	(1.5E-06)
	[0.91679]	[-0.57095]	[-0.59900]	[2.12365]	[1.45160]	[-0.30386]

D(EC(-1))	-0.001060	-1883265.	0.000308	3705644.	-0.123394	165.7704
	(0.00067)	(1854195)	(0.00024)	(1.0E+07)	(0.43616)	(84.9546)
	[-1.58918]	[-1.01568]	[1.30405]	[0.36370]	[-0.28291]	[1.95128]
D(EC(-2))	-0.000425	-67073.04	0.000739	20133996	-0.083165	196.3005
	(0.00069)	(1920712)	(0.00024)	(1.1E+07)	(0.45181)	(88.0023)
	[-0.61529]	[-0.03492]	[3.02477]	[1.90767]	[-0.18407]	[2.23063]
D(EC(-3))	-0.000155	-1249705.	0.000185	4880193.	-0.151128	-32.31787
	(0.00071)	(1975625)	(0.00025)	(1.1E+07)	(0.46473)	(90.5182)
	[-0.21799]	[-0.63256]	[0.73646]	[0.44954]	[-0.32520]	[-0.35703]
D(SQUARED_GDP(-1))	2.04E-07	13273.08	5.43E-07	-59469.99	9.70E-05	-0.827611
	(2.4E-06)	(6765.32)	(8.6E-07)	(37175.2)	(0.00159)	(0.30997)
	[0.08397]	[1.96193]	[0.63084]	[-1.59972]	[0.06097]	[-2.66997]
D(SQUARED_GDP(-2))	-4.38E-07	4774.571	1.66E-07	-46676.57	-0.001214	-0.777863
	(2.1E-06)	(5942.55)	(7.6E-07)	(32654.1)	(0.00140)	(0.27227)
	[-0.20474]	[0.80345]	[0.21948]	[-1.42942]	[-0.86855]	[-2.85692]
D(SQUARED_GDP(-3))	-2.05E-07	-4643.316	6.11E-07	-48735.68	-4.55E-05	-0.882389
	(1.9E-06)	(5311.17)	(6.8E-07)	(29184.7)	(0.00125)	(0.24334)
	[-0.10727]	[-0.87425]	[0.90384]	[-1.66991]	[-0.03640]	[-3.62609]
C	-0.029324	2.35E+08	0.006599	6.79E+08	-4.077032	26145.06
	(0.03838)	(1.1E+08)	(0.01357)	(5.9E+08)	(25.0875)	(4886.48)
	[-0.76402]	[2.20575]	[0.48639]	[1.15894]	[-0.16251]	[5.35049]
R-squared	0.272959	0.795490	0.778128	0.704776	0.311684	0.797910
Adj. R-squared	-0.204161	0.661281	0.632524	0.511034	-0.140024	0.665288
Sum sq. resids	0.515151	3.98E+18	0.064380	1.20E+20	220098.5	8.35E+09
S.E. equation	0.126880	3.53E+08	0.044854	1.94E+09	82.93418	16153.68
F-statistic	0.572097	5.927233	5.344147	3.637719	0.690013	6.016429
Log likelihood	48.98884	-1125.255	105.1395	-1217.262	-301.0695	-585.7498
Akaike AIC	-0.999587	42.49094	-3.079240	45.89860	11.96554	22.50925
Schwarz SC	-0.189260	43.30127	-2.268913	46.70893	12.77587	23.31958
Mean dependent	-0.020817	5.45E+08	-0.019718	-3.21E+08	0.000000	25524.64
S.D. dependent	0.115625	6.06E+08	0.073992	2.77E+09	77.67417	27921.31

Estimated VECM:

$$\Delta CO2_t = -0.0293 - 0.4949\Delta CO2_{t-1} - 0.7175\Delta CO2_{t-2} - 0.3003\Delta CO2_{t-3} +$$
$$4.31E-13\Delta Ind_{t-1} - 4.68E-11\Delta Ind_{t-2} + 4.20E-11\Delta Ind_{t-3} + 0.0994\Delta Urb_{t-1} + 0.0148\Delta Urb_{t-2} - 0.0434\Delta Urb_{t-3}$$
$$\sum_{i=0}^{n} + 5.09E-12\Delta IT_{t-1} + 4.06E-13\Delta IT_{t-2} + 1.07E-11\Delta IT_{t-3} - 0.0010\Delta EC_{t-1} - 0.0004\Delta EC_{t-2} - 0.0001\Delta EC_{t-3}$$
$$+ 2.04E-07\Delta GDP^2{}_{t-1} - 4.38E-07\Delta GDP^2{}_{t-2} - 2.05E-07\Delta GDP^2{}_{t-3} + 0.5031ect_{t-1} - 1.69E-11ect_{t-2} + 0.0162ect_{t-3}$$

As we know that we identified 3 co integrating equation or error correction terms in VECM model as shown above, therefore, following are the 3 estimated co integrating equations.

Equation 01:

$$Z_{t-1} = ECT_{t-1} = 1.0000CO2_{t-1} - 1.7492 - 0.000Ind_{t-1} - 0.000Urb_{t-1} - 1.02E-10IT_{t-1} + 0.0016EC_{t-1} - 1.07E-06GDP^2{}_{t-1}$$

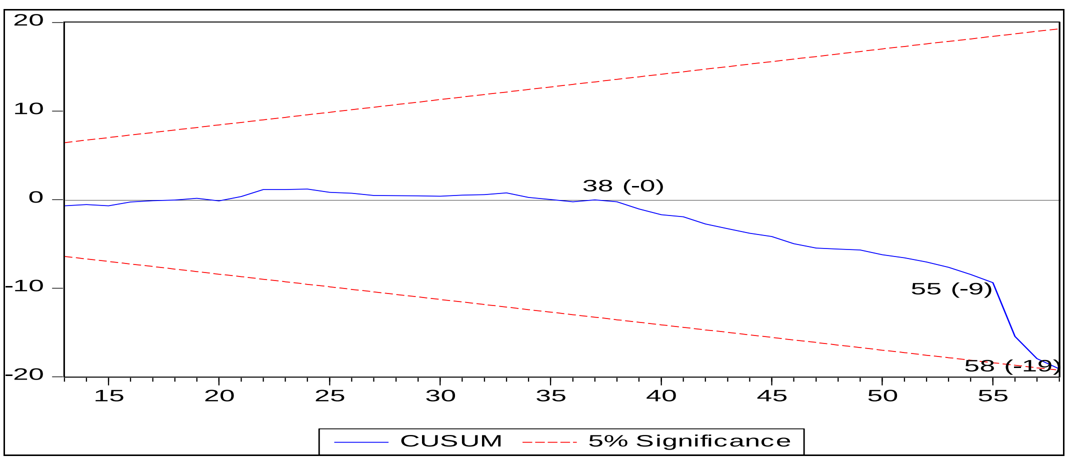
Equation 02:

$$Z_{t-1} = ECT_{t-1} = 0.00CO2_{t-1} - 1.31E^{+10} + 1.00Ind_{t-1} - 0.00Urb_{t-1} - 2.3179IT_{t-1} - 2494970EC_{t-1} - 36276GDP^2{}_{t-1}$$

Equation 03:

$$Z_{t-1} = ECT_{t-1} = 0.00CO2_{t-1} - 6.3659 + 0.00Ind_{t-1} + 1.00Urb_{t-1} - 3.93E^{-10}IT_{t-1} - 0.0046EC_{t-1} - 3.83E^{-07}GDP^2{}_{t-1}$$

Now we can check the structural breaks to verify, there exists 3 structural breaks which makes 3 co integrating equations.



From above figure we can first conclude the stability among coefficients because the two straight lines (i.e. red line) representing two statistics bound by the 5% significant level, authenticate the stability of model because blue line of data lie within the boundaries of red lines. Second, we can clearly see that there exist 2 structural breaks and/or 3 co integrating equations (i.e. one from 1year which is 1960 to 38th year which is 1998, second from 38 which is 1998 to 55th year which is 2014 and 3rd from 55 which is 2014 to 58th year which is 2017). Moreover, according to this data set that after 38 years in 1998, environmental degaradation started to decrease. The results are consistent with EKC hypothesis.

CONCLUSION AND RECOMMENDATIONS

The study concluded that Industrialization and Energy Consumption positively and significantly contribute in deteriorating the environment in Pakistan. Thus, we can say that as country shift to industrialization and use more energy; it drastically deteriorates the environmental condition in Pakistan. Furthermore, International Trade has no effect on environmental degradation. This may be because of the reason such as, one, Pakistan import more than it exports therefore; it requires less harmful industrial productions. Second, Pakistan largely exports raw material such as cotton bales, meat, timber etc. and agriculture products such as fruits, vegetables, etc. which does not require huge industrial production which could become cause of CO2 emission or environmental degradation. In addition, Urbanization significantly yet negatively affects CO2 emissions. Meaning that, as people shift from rural to urban areas, it improves the environmental conditions in Pakistan.

Finally, the negative coefficient of GDP^2 and its probability value less than 0.05 suggests significant and negative effect on environmental degradation. Therefore, we can conclude that when GDP per capital reaches the turning point, the environmental degradation starts to decrease significantly. This is because at this stage, the country starts investing in environmental improvements and implementing rules and regulations for industrial processes to protect the society from environmental damages. These results of our research are consistent with the Environmental Kuznets Curve (EKC), which states that at the initial stage, country's income increases at the expense of environmental degradation. However, at the later stage when income or GDP squared or reach the turning point, the environment gets improve, because benefits of the country's income are shared with the overall society.

RECOMMENDATION

It is recommended from this research that:

There should be stringent policy to make industries liable for protecting environment. Government should launch a massive promotion program where awareness regarding environmental degradation and their effects on human life can be promoted in the public. Keeping in view the severity of environmental degradation, climate change and global warming, all the stakeholders including, public, business organizations and government should start green campaign to plant trees throughout Pakistan to reduce the severity.

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