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Environmental Impact of Economic Growth: Empirical Evidence from Pakistan

Allah Ditta[1], Muhammad Ayub[2], Kashif Raza[3], Salyha Zulfiqar Ali Shah[4]

[1] Assistant Professor of Economics, Govt. College Township, Lahore Higher Education Department, Govt. of the Punjab, Pakistan. Email: ad.tahir77@gmail.com
[2] Assistant Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan. Email: mayub@bzu.edu.pk
[3] Lecturer, Department of Economics, The Islamia University of Bahawalpur, Pakistan. Email: kashif.raza@iub.edu.pk
[4] Assistant Professor, School of Economics, Bahauddin Zakariya University, Multan, Pakistan. Email: salyhazulfiqar@bzu.edu.pk

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ABSTRACT

Environmental degradation as a consequence of modern technological change is still an unresolved global issue. As countries grow, the cost of this progress has to be born in the form of a rise in carbon emissions. In Pakistan, energy consumption has increased from 34 Million MTOE in 1992 to 98 MTOE in 2019 due to oil and gas-based production. Likewise, the average temperature has risen during the last 50 years in Pakistan. Based on IPAT and Climate change models, this study estimates the two equations model to analyze the impact of economic growth, foreign direct investment, population density and population in urban agglomeration on carbon emissions by using ARDL bound testing methodology. The co-integration relationship was found in both stages with consistency. This study proved the Environmental Kuznets curve (EKC) theory in the case of Pakistan. The more insightful finding is that the large bulge area of the curve between carbon emissions and economic growth highlights that the negative impact of today's economic growth on the environment will remain for a much longer period in the future. It is also found that carbon emissions are responsible for increasing average temperature resulting in a climatic change in Pakistan. These empirical results indicate that there is a dire need to revisit the growth strategy to achieve sustained economic growth.

Corresponding Author's Email: mayub@bzu.edu.pk

1. Introduction

Environmental degradation through rising greenhouse gases and other pollution is one of the alarming issues both at the global and regional levels. The deterioration of the environment has a direct impact on climate change through rising temperature and causing threats to human living. Air pollution becomes the reason for several respiratory problems and other diseases.

In the last three decades, overall energy consumption in Pakistan has increased due to increasing economic activity and population pressure like many developing economies. According to WDI statistics, energy consumption has increased from 34 Million Tons of Oil Equivalent (MTOE) in 1992 to 98 MTOE in 2019. So, the carbon emissions increased more rapidly during the same period and likewise, the average temperature has also risen in Pakistan. The trends explain that the largest increase has occurred in the electricity and heat production sector i.e. from 20.2% in 1970 to 35% in 2010. It explains the overdependence of energy generation on oil. On one side, it is an expensive method of energy production thereby increasing the cost of production and making our products less competitive in international markets. On the other side, it is responsible for adding more CO_2 to the atmosphere which results in an increasing trend of average temperature in Pakistan. Increasing temperature is one of the fundamental reasons for climate change in Pakistan. As we know that the major source of energy in Pakistan is non-renewable energy, which emits CO_2 at the rate of 6 percent per year (Iram & Fatima, 2008). It is expected that CO_2 emissions in Pakistan will reach around 400 million tons by 2030, leaving a poor environment in the country (Masood, Farooq, & Saeed, 2015). The continuous emission of carbon dioxide into the atmosphere adversely affects the environmental quality in Pakistan (Santos-Paulino, 2012). It is increasing the average temperature level badly affects the health of the people in the form of diseases like cardiac arrest, cancer and other chronic diseases. Moreover, also a reason for rising sea levels, unusual rainfall patterns, and increased intensity of storms.

The decade-wise composition of sector-wise CO2 emissions from 1970 to 2019 in Pakistan is shown in table 1 below.

Table 1
***CO2 Emissions by Sector*[1]**

Year	Transport	Manufacturing & Construction	Electricity and Heat Production	Residential and Commercial services	Other
1970-1979	24.3	37.4	20.2	23.9	5.3
1980-1989	27.3	31.1	22.2	17.3	2.0
1990-1999	26.8	27.1	32.2	12.6	1.2
2000-2009	26.3	28.5	33.3	11.3	0.5
2010-2019	29.2	23.1	35.0	12.3	0.3

The primary goal of this research is to determine how economic expansion affects CO2 emissions (environmental quality) in Pakistan. The research will look into how CO2 affects climate change by raising temperatures.

2. Literature Review

Varvarigos (2008) found out that life expectancy, capital and environmental quality affected economic growth significantly. The most central conclusion of this study was that if technology causes pollution above bearable level, it leads to a downward growth cycle and will return to a long-run position. On the other hand, if technology causes pollution below a critical level, it leads to an upward growth cycle. It concludes that environmental quality and economic growth have a negative relationship (Nawab, Bhatti, & Nawaz, 2021).

Florides and Christodoulides (2009) estimated the impact of CO2 emissions on temperature increase by using three independent data sets taken from chemistry and ice core. They used adiabatic and ESMs models and concluded that an increase in CO2 concentration in the atmosphere not only causes an increase in temperature but also causes a change in the physiology of plants.

Using a panel data set of 29 provinces from 1992 to 2004, Bao, Chen, and Song (2011) studied the impact of foreign direct investment (FDI) on emissions of five pollutants in China. The magnitude, technique, and composition effects of FDI on China's total and regional pollution emissions are estimated using simultaneous equations estimating technique. The estimation

[1] Author’s calculation based on WDI data.

results reveal that FDI in general aids in the reduction of pollution emissions in China, with the method effect playing a substantial role. The accuracy of analyzing the FDI's environmental impact is improved by capturing both direct and indirect methodological effects. The study also discovered that the environmental implications of FDI in China vary dramatically between areas and for various pollutants.

Mahmood and Chaudhary (2012) researched Pakistan to determine the influence of foreign direct investment on carbon dioxide emissions. The dependent variable is carbon dioxide emissions, while the independent variables are foreign direct investment, manufacturing value-added, and population density. The unit root problem was found using the ADF, PP, Ng-Perron, and Zivot-Andrews unit root tests. The long and short-run correlations were discovered using ARDL and its error-correcting model. The study discovered a long-run relationship in the model, but no short-run relationship. The influence of foreign direct investment, manufacturing value-added, and population density on carbon dioxide emissions are positive (Nawaz, Ahmadk, Hussain, & Bhatti, 2020).

Shahbaz, Lean, and Shabbir (2012) have done an empirical study for a single country Pakistan that investigates the relationship between CO_2 emissions, energy consumption, economic growth and trade openness. In Pakistan, energy consumption has increased due to industrial-led growth strategy, high use of petroleum for transportation purposes and use of natural gas for electricity production. This study is an attempt to fill the gap in energy consumption literature that will be useful for policy-making authorities to design policies for the protection of the environment. The econometric technique of time series for analyzing the empirical relationship among variables covering the time period 1971-2009 has been applied. The empirical findings indicate that variables promoting EKC in Pakistan have a long-term association.

Chandran and Tang (2013) looked into the effects of transportation energy consumption, foreign direct investment, and income in emerging countries on CO2 emissions. They use co-integration and Granger causality approaches to examine the influence of energy consumption in the transportation sector and foreign direct investment on CO2 emissions (Fazal, Gillani, Amjad, & Haider, 2020; Granger, 1969). According to the long-run elasticity estimation, income and transportation energy use have a considerable impact on CO2 emissions, whereas FDI has little effect. In emerging countries, economic growth is a bigger contributor to CO2 emissions (Gillani & Sultana, 2020).

The impact of foreign direct investment and economic growth on CO2 emissions was explored by (Shaari, Hussain, Abdullah, & Kamil, 2014). Data from 15 developing nations were collected during the period 1992 to 2012. The results of the Johansen co-integration showed that the variables are cointegrated (FDI, CO2 and GDP). Then, using fully modified ordinary least squares (FMOLS), the study discovered that foreign direct investment has no impact on CO2 emissions in the long run.

Studies by Azam (2016); Omri, Daly, Rault, and Chaibi (2015) Nawaz, Azam, and Bhatti (2019) explore that there is a negative relationship between economic growth and environmental quality. Anderson, Hawkins, and Jones (2016) analyzed the impact of CO2 emissions on temperature by using Earth System Models (ESMs). They concluded that CO2 emissions cause global warming by increasing average temperature.

Hanif (2017) studied the impact of the expansion of urbanization, electrical energy consumption, oil-based imports and fossil fuel on environmental degradation occurring in the developing countries of Latin America and the Caribbean. GMM methodology with a two-step estimator was applied on the panel data of twenty economies including both middle and lower-middle throughout 1990 to 2015. The empirical results indicate that there is a U-shaped relationship between per capita growth and carbon emissions. It deduced that oil imports, urbanization and fossil fuel significantly contribute to environmental degradation.

Hanif (2018) tested Environmental Kuznets Curve (EKC) by analyzing the effects of economic growth, energy consumption and urbanization on CO2 by taking panel data of twelve East Asian and Pacific countries from 1990 to 2014. The GMM methodology was applied. The results show that economic growth, energy consumption and urbanization all lead to increased carbon emission significantly and hence contribute to environmental degradation. The results also confirmed the existence of the EKC hypothesis.

This study estimated the two-equation model to analyze the impact of economic growth on CO2 and the impact of CO2 on the temperature in one model. Based on the review of literature, the following hypotheses are as under:

H_o: There is an insignificant relationship between Economic Growth and Carbon Dioxide Emission (CO_2)
H_1: There is a significant relationship between Economic Growth and Carbon Dioxide Emission (CO_2)
H_o: There is an insignificant relationship between Carbon Dioxide Emission (CO_2) and average temperature
H_1: There is a significant relationship between Carbon Dioxide Emission (CO_2) and average temperature.

3. Theoretical Underpinnings of IPAT, Climate Models and Data Type

IPAT represents a model linking the sustainability of outputs to three factors. The letters show the rudimentary form of the model, which is: Impact = Population * Affluence * Technology. The IPAT framework signifies the nature of the relationship and causality between carbon emission and the determinants of economic growth, population (volume and density), trade openness, capital formation, poverty gap and income inequality is found different depending upon the geographic structure of each country. Surprisingly, population density serves as the major contributor to environmental degradation, while trade openness improves the environmental quality in the case of Pakistan (Ahmed & Long, 2012). The long-run existence of the Environmental Kuznets Curve (EKC) in Pakistan is due to industrial-led growth strategy, high use of petroleum in transportation purposes and the use of natural gas for electricity production (Bhatti, ur Raheem, & Zafar, 2020; Shahbaz et al., 2012).

The environmental Kuznets Curve primarily hypothesized that at the first stage, environmental degradation occurs with the initial rise in income level. However, it gets better after a certain level of income rise at the second stage because as the average yearly income of the people rises to a certain level, they become more careful about their food and environment which surrounds them.

3.1. Data

The date is taken over the period 1975 to 2019 in the case of Pakistan from world development indicators. A brief description of selected variables and data is in the following table no. 2.

3.2. Econometric Model

The functional form of the selected model is as follows;

$CO_2 = f\ (GDP_{pc}, GDP_{pc}^2, FDI, IPD, UPA)$ (1)

T = f (CO2) (2)

Where;
CO_2 = Carbon Dioxide Emission metric ton per capita (MTPC)
GDP_{pc} = Gross Domestic Product (GDP) per capita is a term used to describe the amount of money earned (Constant LCU)
GDP_{pc}^2 = Gross Domestic Product Squared (Constant LCU)
FDI = Foreign Direct Investment
IPD = Inverse Population Density
UPA = Population in the urban agglomeration of more than 1 million (% of Population)
T = Average yearly temperature (Celsius degree)

Table 2
Description of Variables and Data

Variable Name	Description of Variables and Data		
CO_2	Carbon dioxide emission is taken as the proxy to measure the quality of the environment.		
	Unit	Data Source	Period
	Metric tons Per capita	World Development Indicators, 2018	1975-2019
GDP_{pc}	Gross Domestic Product per capita (GDP_{pc}) in constant terms is taken as a proxy to measure economic growth.		
	Unit	Data Source	Period
	USD	World Development Indicators, 2018	1975-2019
GDP_{pc}^2	The square of Gross Domestic Product per capita is taken as a proxy to measure the existence of the Environment Kuznets Curve (EKC).		
	Unit	Data Source	Period
	USD	World Development Indicators, 2019	1975-2019
FDI	Foreign Direct Investment (% of GDP) is taken to discover the effect of inflow of Capital. It is taken at the current rate of USD.		
	Unit	Data Source	Period
	USD	World Development Indicators, 2019	1975-2019
T	Average Yearly Temperature (Celsius)		
	Unit	Data Source	Period
	Degree (Celsius)	World Development Indicators, 2019	1975-2019
IPD = 1/PD	Population Density is how many peoples are living in the area of 1-kilometer (km) square.		
	Unit	Data Source	Period
	No. of People	World Development Indicators, 2019	1975-2019
UPDATE	Population in the urban agglomeration of more than 1 million		
	Unit	Data Source	Period
	% of Population	World Development Indicators, 2019	1975-2019

The model is transformed into a log model. All variables are taken into natural log form to make the analyses simplified. The selected model, in terms of an econometric model, can be written as follow;

First stage

$$lnCO_2 = \beta_0 + \beta_1 lnGDPpc_t + \beta_2 lnGDPpc^2{}_t + \beta_3 lnFDI_t + \beta_4 lnIPD_t + \beta_5 lnUPA_t + \varepsilon_t \quad (3)$$

Second Stage

$$lnT_t = \beta_0 + \beta_1 lnCO2(fitted)_t + \upsilon_t \quad (4)$$

Where,

CO2 (fitted) was taken from the regression of equation 3. The procedure of estimation has three steps. At first, the issue of the unit root was dealt with by using Ng-Perron (2001). The ARDL Bounds Testing Approach was used in the second stage to evaluate the long-run co-integration relationship between the dependent and independent variables, as well as to estimate both the short and long-run coefficients of the independent variables for the dependent variable. The following equation was used to calculate long-run co-integration and coefficients:

$$\Delta CO_{2t} = \propto_1 + \propto_T T + \propto_{CO_2} CO_{2_{t-i}} + \propto_{GDP} GDP_{t-i} + \propto_{GDP^2} GDP^2{}_{t-i} + \propto_{FDI} FDI_{t-i} + \propto_{IPD} IPD_{t-i} + \propto_{UPA} UPA_{t-i} + \sum_{i=0}^{p} \propto_i \Delta CO_{2_{t-i}} + \sum_{i=0}^{q} \propto_i \Delta GDP_{t-i} + \sum_{i=0}^{r} \propto_i \Delta GDP^2{}_{t-i} + \sum_{i=0}^{s} \propto_i \Delta FDI_{t-i} + \sum_{i=0}^{u} \propto_i \Delta IPD_{t-i} + \sum_{i=0}^{v} \propto_i \Delta UPA_{t-i} + \theta ECT_{t-1} + \varepsilon_t \quad (5)$$

And

$$\Delta T_t = \propto_1 + \propto_T T + \propto_T T_{t-i} + \propto_{CO2} CO2\,(fitted)_{t-i} + \sum_{i=0}^{p} \propto_i \Delta T_{t-i} + \sum_{i=0}^{q} \propto_i \Delta CO2(fitted)_{t-i} + \theta ECT_{t-1} + \upsilon_t \quad (6)$$

The above given ARDL model consists of both the constant and trend term in the model. Variables having the term Δ with them are the variables to show the output of the variable in short-run analysis and without the term Δ are variables used for the long-run estimation. ECT_{t-1} is the error correction term in the selected model. It confirms the speed of adjustment from short run to long run in a year. Afterward, the Gregory Hansenco-integration test was applied. After establishing the co-integration with structural break among the variables, the ARDL bound testing methodology was again applied with a structural break to analyze the long-run and short-run relationship among the variables.

4. Findings of the Study

Table 3
Descriptive Statistics

Variables	LNCO2	LNFDI	LNGDPP	LNGDPP2	LNIPD	LNT	LNUPA
Mean	-0.42	-0.54	10.62	112.86	-5.10	3.01	16.92
Median	-0.32	-0.49	10.64	113.20	-5.14	3.02	16.94
Maximum	-0.02	1.30	11.07	122.50	-4.46	3.08	17.60
Minimum	-1.10	-2.79	10.12	102.41	-5.64	2.97	16.15
Std. Dev.	0.33	0.88	0.26	5.40	0.35	0.03	0.42
Skewness	-0.69	-0.25	-0.32	-0.28	0.22	0.11	-0.12
Kurtosis	2.28	3.28	2.26	2.24	1.83	2.51	1.86
Model Diagnostics							
Jarque-Bera	4.56	0.63	1.78	1.65	2.93	0.54	2.53
Probability	0.10	0.73	0.41	0.44	0.23	0.76	0.28
Sum	-18.86	-24.25	477.93	5078.74	-229.62	135.61	761.19
Sum Sq. Dev.	4.72	33.83	2.87	1284.04	5.52	0.03	7.84
Observations	45	45	45	45	45	45	45

Table 4
Coefficient of Correlation

Variables	LNFDI	LNGDPP	LNGDPP2	LNIPD	LNUPA	LNT
LNFDI	1.00					
LNGDPP	0.71	1.00				

LNGDPP2	0.71	1.00	1.00			
LNIPD	-0.69	-0.99	-0.99	1.00		
LNUPA	0.67	0.99	0.99	-1.00	1.00	
LNT	0.39	0.65	0.65	-0.67	0.68	1.00
LNR	-0.07	-0.13	-0.12	0.16	-0.15	-0.38

Tables 3 and 4 show the results of variable descriptive statistics and the variance inflation factor (VIF). Jarque-Bera P-values are typically distributed, according to the research. There is no issue of multicollinearity in this study because all of the coefficients of correlation and variance inflation factor (VIF) are less than 10.

Table 5
VIF

Variables	LNFDI	LNGDPP	LNGDPP2	LNIPD	LNUPA	LNT
LNFDI	-					
LNGDPP	-2.36	-				
LNGDPP2	-2.41	-1.00	-			
LNIPD	0.42	0.34	0.34	-		
LNUPA	-2.86	-1.03	-1.03	0.33	-	
LNT	4.70	-3.40	-3.33	0.43	-2.83	
LNR	0.88	0.80	0.80	1.48	0.76	

The unit root test by using ADF and Phillip-Perron methodologies was estimated and shown in table 6 below. The values of ADF and PP are showing the mixed order of integration. As a result, the ARDL bound testing methodology was used to estimate the long-run relationship as well as the long and short-run values of the parameters.

Table 6
ADF and Phillip Perron Unit Root Test

Variable	ADF		PP		Stationary
	Level	The First Difference	Level	The First Difference	
LNCO2	0.245	0.000	0.233	0.000	I(1)
LNFDI	0.292	0.000	0.266	0.000	I(1)
LNGDPP	0.767	0.001	0.750	0.001	I(1)
LNGDPP2	0.822	0.001	0.811	0.001	I(1)
LNIPD	0.037	0.047	0.000	0.084	I(0)
LNUPA	0.041	0.089	0.000	0.001	I(0)
LNT	0.816	0.000	0.752	0.000	I(1)
LNR	0.160	0.000	0.001	0.000	I(1)

Equation 5 was estimated by using the same methodology and the results are shown in table 7. The calculated F- statistics are higher than its respective critical values at 5%, which explains the existence of a long-run relationship between CO2 and its determinants.

Equation 6 was also estimated by using ARDL bound testing methodology and the results are shown in table 8. The calculated F- statistics is greater than its respective critical values at 5%, which again shows the existence of a long-run relationship between Temperature and CO2.

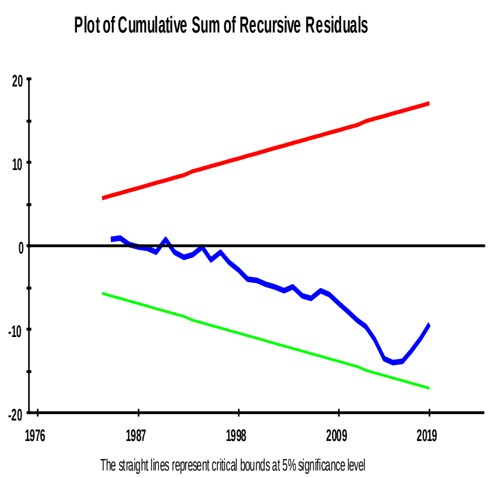
The diagnostic tests for examining the serial correlation, functional form, normality and heteroscedasticity among the variables are presented in table 5.6A and 5.6B below. The p-values of all diagnostics are equal or greater than 1, which accepts the null hypotheses that there is no issue of any of the diagnostics in the estimation. There is no issue of a structural break as well as shown in the figure below;

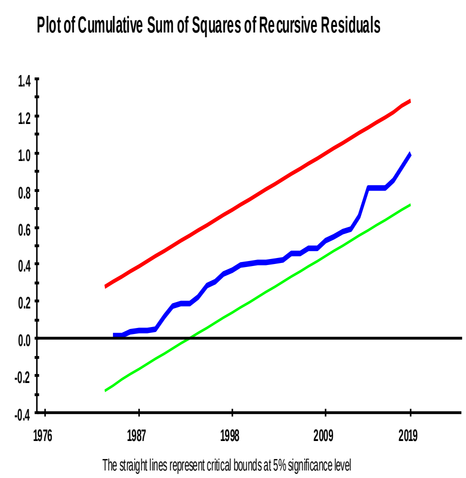
Table 7
ARDL bound testing approach

Estimated Model		$Ln(CO2_t) = f(LnGDPP_t, LnGDPP2_t, LnFDI_t, LnIPD_t, LnUPA_t)$	
Optimal Lags	(1,0,0,1, 0, 1)		
F – Statistics		6.19**	
Significance level		**Critical bounds for F – statistics**	
	Lower Critical Bound		Upper Critical Bound
5 percent	2.96		3.79
10 percent	2.62		3.79
		Diagnostic Tests	
R^2	0.98	*Serial Correlation*	1.13[.334]
Adjusted R^2	0.96	*Functional Form*	1.111[.292]
F – Statistics	103.04	*Normality*	0.188[.910]
P – Value (F Statistics)	0.000	*Heteroscedasticity*	0.455[.946]
DW – Statistics	2.2		

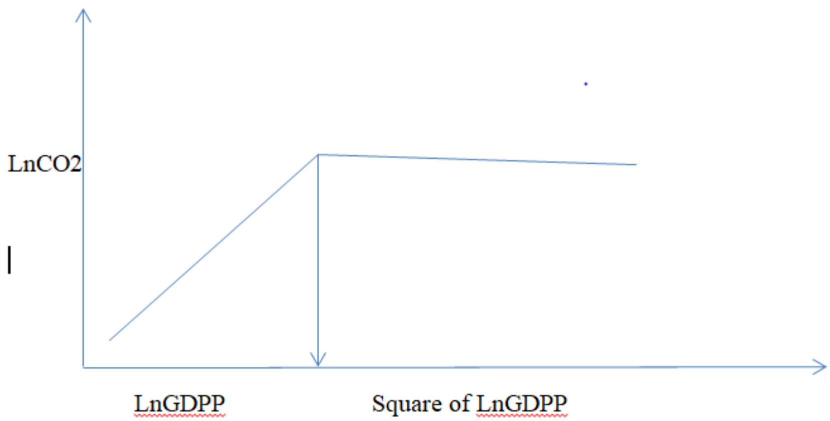
Table 8
ARDL bound testing approach

Estimated Model			$Ln(T_t) = f(EC02_t)$	
Optimal Lags		(1,0)		
F – Statistics			14.53**	
Significance level			**Critical bounds for F – statistics**	
		Lower Critical Bound		Upper Critical Bound
5 percent	4.94		5.73	
10 percent	4.04		4.78	
			Diagnostic Tests	
R^2		0.33	*Serial Correlation*	1.13[.334]
Adjusted R^2		0.29	*Functional Form*	1.12[.354]
F – Statistics		9.9	*Normality*	0.188[.910]
P – Value (F Statistics)		0.000	*Heteroscedasticity*	0.773[.62]
DW – Statistics		1.9		





The long-run and short-run dynamics of LnCO2 along with its determinants are shown in table 9 below. Both in the long run and short run the positive and significant impact of lnGDPP and the negative and significant impact of the square of lnGDPP on LnCO2 testifies the presence of EKC in the case of Pakistan. The long-run coefficient of lnGDPP is 6.81 and the long-run coefficient of the square of lnGDPP is -0.29. This shows that the bulge area of the curve is wide enough to show the negative impact of the current growth of LnGDPP on the environment would remain for a much longer period in the future as shown in the figure below:



The turning point as shown in the above figure is calculated as under:

Turning point = antilog of – (0.5 × Coefficient attached with GDP per capita / Coefficient attached with the quadratic term of GDP per capita)

Turning Point = antilog of – (0.5 X 6.8/-0.292)

Turning Point = 38.66 percent, which explains that after a 38.6% increase in the current GDP, the impact of GDP on environmental degradation will be negative. The logic here is that with the increase in GDP per capita, the people generally and manufacturers/businessmen particularly will be wealthier and would adopt environment-friendly technologies in their consumption and production behaviors. In the context of Pakistan, due to lack of resources, there is poor management of wastes which cause environmental degradation (Ejaz, Akhtar, Hashmi, & Naeem, 2010).

LnFDI has a positive and considerable impact on LnCO2 in both the long and short term. The coefficient value, in the long run, is 0.02 whereas in the short run it is 0.028. It illustrates that a 1% increase in FDI causes a 0.20 percent rise in long-term carbon emissions and a 0.028 percent increase in short-term carbon emissions. Through two channels, FDI contributes to environmental degradation in Pakistan. The first is the infusion of FDI into the electricity generating and manufacturing sectors, particularly the leather industries, which result in substantial CO2 emissions in terms of both quantity and rate. The contribution of FDI to capital formation in the same industries is the second source of FDI (Mahmood & Chaudhary, 2012).

LnUPA has a negative and statistically significant impact on LnCO2 in both the short and long term. The coefficient value, in the long run, is -0.792, whereas in the short run it is -4.197. It explains that a 1 percent increase of people living in urban agglomeration causes a 4.197 percent decrease in carbon emissions in the short run and a 0.792 percent decrease in the long run. In Pakistan, there is a constant increase in urban population mainly because of migration from rural to urban. Due to this fact, there is increasing demand for transportation and other consumers goods which cause high CO_2 emissions. To reduce the positive impact of urbanization on CO2 emissions as highlighted by Yu, Wu, Zheng, Li, and Tan (2020) in the case of China, there is a need to develop urban agglomerations to achieve economies of scale and bring sustained growth. The value of ECM_{t-1} is -0.85 which explains that the mean value of LnCO2 will return to its long-run path of mean values just in 1.17 years.

The impact of explained LnCO2 (estimated from equation 5) on LnT is given below in table 10. The impact of LnCO2 on LnT is found highly significant and positive. It explains that the core reason for increasing temperature in Pakistan is the increasing quantity of CO2 emissions in the air. The increasing temperature is responsible for climate change- more floods, more droughts, unseasonal rain, and more rainfall, increasing health diseases (combating climate change, 2011). The increasing CO2 emissions are due to the wrong energy equation in Pakistan as highlighted above. There is a dire need to revisit the growth strategy and correct the energy equation so that we may achieve sustained economic growth.

Table 9
Long-run and Short-run Dynamics

Estimated Long run Coefficients using		**Error Correction Representation for the Selected**	
Dependent Variable : $LnCO2_t$		**Dependent Variable : $\Delta LnCO2_t$**	
Variables	Coefficient [P – Value]	Variables	Coefficient [P – Value]
$LnGDPP_t$	6.81 [.032]	$\Delta LnGDPP_t$	5.846 [.035]
$LnGDPP2_t$	-0.292[.051]	$\Delta LnGDPP2_t$	-0.25[.054]
$LnFDI_t$	0.052[.000]	$\Delta LnFDI_t$	0.028[.003]
$LnIPD_t$	-1.259 [.025]	$\Delta LnIPD_t$	-1.080[.059]
$LnUPA_t$	-0.792[.100]	$\Delta LnUPA_t$	-4.157 [.092]
C	-32.672[.106]	ECM_{t-1}	-0.859 [.000]
Diagnostics for ECM Model			
R^2	0.801	$Mean\ Dependent\ Variable$	0.023
$Adjusted\ R^2$	0.78	$S.D. Dependent\ Variable$	0.034
$S.E. of\ Regression$	0.024	$Akaike\ Information\ Criterion$	-4.4
$Sum\ Squared\ Residual$	0.02	$Schwarz\ Information\ Criterion$	-4.03
$Log\ Likelihood$	105.83	$DW - Stat$	2.33
$F - Statistics$	6.608	$Prob. Value\ [F - Statistics]$	0.000

The Gregory Hansen Test for co-integration was applied. The results are shown in Table 5.8 below. The calculated values of ADF and Zt in absolute terms are higher than their critical values at 1%, at breakpoint year, 2012. The results of the ARDL bound testing approach with a structural break are shown in table 11 below. The findings show that CO2 emissions and their components with a structural break are co-integrated.

Table 10
Gregory Hansen Test for Co-integration with Regime Shifts

	Test statistics	**Breakpoint**	**Date**	**Asymptotic Critical Value**		
				1%	5%	10%
ADF	**-7.97**	**38**	**2012**	**-6.36**	**-5.83**	**-5.59**
Zt	**-8.06**	**38**	**2012**	**-6.36**	**-5.83**	**-5.59**
Za	-52.09	38	2012	-76.95	-65.44	-60.12

Table 11
ARDL bound testing approach with Structural Break

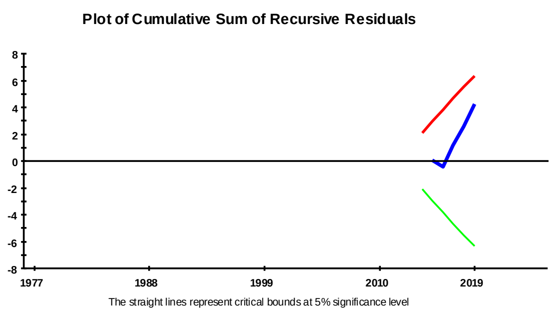
Estimated Model	$Ln(CO2_t) = f(LnGDPP_t, LnGDPP2_t, LnFDI_t, LnIPD_t, LnUPA_t, d12)$		
Optimal Lags	(2,1,2,2,2,0,1)		
F – Statistics		3.67	
Significance level		**Critical bounds for F – statistics**	
	Lower Critical Bound		Upper Critical Bound
5 percent	2.7	4.13	
10 percent	2.33		3.56
		Diagnostic Tests	
R^2	0.99	$Serial\ Correlation$	.253[.614]
$Adjusted\ R^2$	0.99	$Functional\ Form$	.156[.692]
$F - Statistics$	535	$Normality$	1.481[.477]

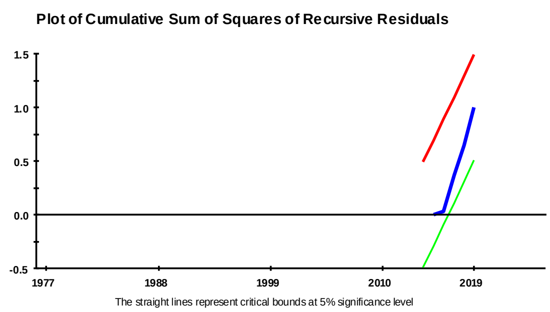
$P-Value$ $(F\ Statistics)$	0.000	$Heteroscedasticity$	.198[.657]
$DW-Statistics$	1.91		

The long-run and short-run coefficient values of the independent variables are given in table 12 below. The results show that the coefficient value of GDP per capita is positive and significant as it was without a structural break. However, the coefficient value is lower than the value without a structural break. Both in the long and short run, the coefficient value of FDI is positive and significant, just as it was before the structural rupture. Both in the long and short run, the value of the structural break dummy is negative and highly significant.

Table 12
Long run and Short-run Dynamics with Structural Break

Estimated Long run Coefficients using **Dependent Variable : $LnCO2_t$**		**Error Correction Representation for the Selected** **Dependent Variable : $\Delta LnCO2_t$**	
Variables	Coefficient [P – Value]	Variables	Coefficient [P – Value]
$LnGDPP_t$	5.27 [.097]	$\Delta LnGDPP_t$	-14.28 [.230]
$LnGDPP2_t$	-0.21[.148]	$\Delta LnGDPP2_t$	0.728[.205]
$LnFDI_t$	0.044[.000]	$\Delta LnFDI_t$	0.320[.011]
$LnIPD_t$	-1.125 [.075]	$\Delta LnIPD_t$	2.30[.813]
$LnUPA_t$	-0.597[.248]	$\Delta LnUPA_t$	-.891 [.264]
$Lnd12_t$	-0.065[.002]	$\Delta Lnd12_t$	-0.062 [.045]
C	-27.12[.193]	ECM_{t-1}	-1.49 [.000]
Diagnostics for ECM Model			
R^2	0.75	$Mean\ Dependent\ Variable$	0.025
$Adjusted\ R^2$	0.60	$S.D.\ Dependent\ Variable$	0.033
$S.E.\ of\ Regression$	0.021	$Akaike\ Information\ Criterion$	98.83
$Sum\ Squared\ Residual$	0.0112	$Schwarz\ Information\ Criterion$	83.86
$Log\ Likelihood$	115.83	$DW-Stat$	1.91
$F-Statistics$	7.41	$Prob.Value\ [F-Statistics]$	0.000





5. Conclusion and Policy

This study for the first time developed an integrated model based on IPAT (also tested EKC) and Climate change models together to estimate the long-run impact of economic growth of Pakistan and its variants on CO2 emission on the first stage and the impact of CO2 on temperature level on the second stage. To evaluate both the long-run and short-run relationship among the variables, two equations models were estimated using ARDL bound testing methods. At the first stage, there was co-integration between carbon emissions and GDP per capita, foreign direct investment, the inverse of population density, and people living in urban agglomerations, and at the second stage, there was co-integration between average temperature and carbon emissions. The relationships between variables were also found statistically significant in the short run in both stages. This establishes a consistent relationship among the variables. It highlights that the carbon emissions are affected by the selected independent variables for all periods in the first stage and the average temperature is affected by carbon emissions in all periods.

This study proved the EKC theory in the case of Pakistan. LnGDPP has a considerable and favorable influence on CO2 emissions, according to the estimations, while the square of lnGDPP square has a negative and significant impact on CO2 emissions. The more insightful point here is that the long-run coefficient value of lnGDPP is much higher than the coefficient value of the square of LnGDPP. This shows that the bulge area of the curve is so large. It explains the negative impact of economic growth on the environment at the first stage of development would remain for a much longer period in the future. The impact of LnFDI on LnCO2 is positive and significant both in the long run and short run. It expounds the inflow of FDI into the carbon emission industrial sector of Pakistan which includes the Oil refineries, tanneries, Independent Power Plants producing electricity and transport sector. The impact of LnIPD (inverse population density) on LnCO2 is negative and significant both in the long run and short run. This sparkling result highlights the importance of a well-designed policy of urbanization in which the size and population density may be controlled to save the environment. The impact of LnUPA on LnCO2 is negative and statistically significant both in the short run and in the long run. It highlights the importance of developing urban agglomerations in urban cities to control environmental degradation.

This fact gives the direction for the policy of urbanization which may lead to urban agglomeration. The value of ECM_{t-1} is -0.85 which explains that the mean value of LnCO2 will return to its long-run path of mean values just in 1.17 years. The impact of explained LnCO2 (estimated from equation 5) on LnT is given below in table 5.8. The impact of LnCO2 on LnT is found highly significant and positive. It explains that the core reason for increasing temperature in Pakistan is the increasing quantity of CO2 emissions in the air. The increasing temperature is responsible for climate change, more floods, more droughts, unseasonal rain, and more rainfall, increasing health diseases. The increasing CO2 emissions are due to the wrong energy equation in Pakistan as highlighted above. There is a dire need to revisit the growth strategy and correct the energy equation so that we may achieve sustainable economic growth. The environmental sustainability concept should be popularized to avoid jeopardizing the capability of future generations to fulfill their needs. "Green growth" strategy is an alternative way that may be used to achieve sustained economic growth instead of typical industrial economic growth. The green growth strategy sustainably involves natural resources utilization. Deforestation should be stopped and more horticulture is needed to be encouraged. The carbon dioxide emissions should be minimized through proper planning and pollution taxes.

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