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EKC ANALYSIS FOR VARIOUS AIR CONTAMINANTS IN PAKISTAN

Ehsanullah*
Department of Economics, Hannam university, South Korea
ehsan3171@gmail.com

ABSTRACT
This manuscript empirically studies the association between economic growth and environmental scarcity for a developing nation, Pakistan, through the era 1970–2018. The study is prepared for the environmental Kuznets curve (EKC) theory by applying cointegration analysis. Different air pollutants (CO2, CO, NOx, PM10 and SO2) are considered as the environmental variants, and GDP as an economic indicator. Using the ARDL bound test method, the results show that there is a long run cointegrating relation in some variables and that it does not exist in others. An inverted U-shaped linkage between pollution and economic evolution has been found in some pollutants. This implies that emission reduction policies and additional investments in pollution reduction will not disrupt economic growth and may be a realistic policy plan for the host country to achieve long-term ecological development.
Keywords: environmental Kuznets curve, air pollutants, ARDL cointegration, economic growth, ecological development

INTRODUCTION
The connection between economic development and the environmental quality has been exceptional investigation in the course of current period. A few experimental examinations proposed an Inverted-U-shaped link between growth, typically estimated as capita per income, and the environmental quality. On the other hand, at the primary phase of economic progress and environmental degradation rises according to capita per income. As long as the capita per income goes up the value of the contamination goes down. This process is known as Environmental Kuznets Curve (EKC) (Bradford et al., 2005a; Cole, 2004; Gene M. Grossman 1991, n.d.).

As per EKC theory, economic development will be the solution for environmental issues later on. Anyhow, the announced experimental outcomes and ends are confusing. From one perspective, a few experimental investigations have affirmed the presence of an EKC for various estimations of natural degradation. Then again, a few authors insist no proof supporting the EKC theory and instead of monotonically connection among contamination and per capita income (Day & Grafton, 2003; Egli n.d.; Lindmark, 2002). A large portion of these experimental investigations center around utilizing the cross-country board information to evaluate the link among economic development and environmental indicators.

In any case, considering cross country study to an individual nation's study is another pattern for EKC specialists, as the last can dispose of the issues related with cross country information and permit all the more existence found out structure an assessment in a single nation (Ansari et al., 2020; Saboori, & Sulaiman, 2013). One contributes that, related investigations of individual nations offer a favorable position over cross sectional formulation in carrying the examinations closer to the kinetic, which is the reason of the EKC design (Jalil, & Mahmud, 2009; Zambrano-Monserrate, & Ruano, 2019). In accordance with these statements, this present test is an effort to research the construction among the natural debasement and the economic growth for an emerging country.

Pakistan has unfavorable atmosphere condition that is the reason, Pakistan is one of the most abandoned nations on Earth. Growing temperature is predicted to be higher than the world normal temperature (Ahmed, & Long, 2012). Economic arrangements of Pakistan are generally founded on agribusiness. Temperature is relied upon to rise 4-degree Celsius by year 2100 (Nasir, & Ur Rehman, 2011). Significant level of harmful gases, carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), particulate matter (PM_{10}) and sulfur dioxide (SO_2) in our air are the direct reason for

* Corresponding Author

an unnatural weather change issue while greenhouse gasses (GHGs) contain the sun rays in our climate by not letting them escape once more into upper space (Antweiler, Copeland, & Taylor, 2001; Dinda, & Coondoo, 2006). Anthropogenic exercises and deforestation are no doubt the manners in which are swelling the concentration of GHGs in our environment (Managi, & Jena, 2008; Nasir, & Ur Rehman, 2011; Shahbaz, Tang, & Shahbaz, 2011; Song, Zhang, & Wang, 2013). Breathing issues like asthmatic conditions will in general increment in the kids and people which are presented to condition legitimately as a result of expanded grouping of SO_2 and PM_{10} (Aqeel, & Sabihuddin Butt 2001). Therefore, for minimizing these harmful emissions the nation needs to be managed it energy and industrial sector for getting the better economic system (Lotfalipour, Falahi, & Ashena, 2010).

The use of energy is mandatory for economic growth because all the manufacturing and consumption actions are directly related to it. The main sources of energy are converted from fossil fuels for the progressive change. The rapid usage of this fuels for efficient progress has commanded to a significant growth in the global emissions of several hesitantly adverse activities. The harmful emissions disturb the human life at big scale by entering into atmosphere. All the air pollutants are very dangerous, but CO_2 is the major source of global warming, which contributes more than 60% outcome of greenhouse gasses (Birdsall, & Wheeler, 1993a).

The effect of the industrial sector is one of the biggest challenges for all types of contamination in Pakistan. In addition to automobiles emissions responsible more than 45% pollution, the industrial pollutants are also creating a huge environmental deficiency. Industrialization to accomplish economic development has caused in worldwide environmental deprivation. While the influences of industrial movement on the natural environment are a main concern in developing and developed regions (Saboori, & Sulaiman, 2013)**.** Agriculture, textile, oil and gas industries are the main point of pollution in Pakistan. Cleaner technologies and best government policies might be useful for controlling this contamination from manufacturing places (Usman et al., 2022).

The economy of Pakistan has demonstrated huge development during the past two decades, thus the energy utilization particularly in modern division has added contamination to nature (Shahbaz, Hooi Lean, & Shahbaz Shabbir n.d.). The greater part of the CO_2 discharge is produced by petroleum gas which is nearly the half of the complete discharge. The CO is usually the result of incomplete combustion and NO_x is usually produced by the high temperature in industry and heavy automobiles. In the same way PM_{10} contains dust from construction places, landfills, agronomy, and industrial sources (Coondoo, & Dinda, 2008). The transportation part develops quickly with coexisting increment the quantity of individual and business vehicles. More popularity and absence of innovation filled up the natural degradation. Although condition is a worldwide issue along these lines, the interest of each and every nation is significant.

Being a creating nation, Pakistan's government has made helpful journey for the sustainable development, as a section Pakistan is likewise one of those nations which declare the national environmental policy (NEP) in 2005. The essential reason for this activity is to protect the regular habitat and guarantee sound air to the residents. The developing economy in all divisions particularly modern, increment in energy application (Coondoo, & Dinda, 2002; Copeland, & Taylor, 2001).

Our motivation is based on the environmental Kuznets curve theory, utilizing time series data and cointegration investigation. The goals of our investigation are to evaluate the idea of the since quite a while ago run connection between per capita income and environmental damages in Pakistan, and to decide if increments in income are related with decreases in environmental humiliation.

Few papers up to this point exist which centers exclusively around Pakistan, where authors look only CO_2 emissions. This paper extends the current research on different toxic substances to acquire more bits of knowledge into the EKC affiliation. Therefore, a progressively detailed conversation on EKC relationship, just as results on economic arrangement making can be made. Along these lines, the curiosity of this examination can be found in dissecting the time series data of Pakistan for substantial pollutants (CO_2, CO, PM_{10}, NO_2 and SO_2) for the period 1979-2018. The economic growth (GDP) per capita, energy consumption (EC) and industrialization (IND) are coded as independent variables. The rest of the paper is structured as follows. Section 2 reviews the EKC literature and shows the advantages of the single country studies compared to cross country studies. Section 3 introduces the data and model specification. Section 4 presents the empirical findings. Finally, some conclusions and recommendations are described in the last section.

REVIEW OF LITERATURE

For the first time, Grossman and Krueger proposed in 1991 that the link between pollutants (SO2 and soot) and per capita income was "inverted U shaped" rather than linear. Environmental Kuznets Curve (EKC) is the name Panayotou gave to the "inverted U" relationship between pollution and income in 1993 (Grossman & Krueger, 1995). According to the EKC hypothesis, in the early stages of economic growth, environmental pollution will raise along with per capita income, but in the medium and long terms, it will gradually decline due to a combination of the structural and technical effects of economic activity and governmental environmental regulations (Badeeb et al., 2017). Numerous academics have debated the existence and form of this idea to varied degrees, but they have not come to a consensus. The scholarly studies that have examined the EKC for carbon emissions have come to the following conclusions (Ahmad et al., 2016; Alam et al., 2016; Apergis, 2015; Awaworyi Churchill et al., 2020; Ozturk & Acaravci, 2013).

Researchers have started looking into the EKC between CO2 emissions and industry-specific economic development (Mahmoodi & Dahmardeh, 2022). There is a wealth of study on GDP as a measure of economic growth and carbon dioxide as a measure of the environment. (Karasoy & Akçay, 2019)use of several econometric methods to establish the EKC hypothesis' validity in China, despite minor discrepancies at the turning point the decoupling between the economy and carbon dioxide and its driving power varies over time for the province level of China. According to (K. Li et al., 2021), rich countries have a better and more consistent decoupling scenario between GDP and CO2 than emerging nations**.** The key causes behind the decoupling process were also trade openness and R&D efficiency effects(S. Li & Li, 2021) . (Neves & Marques, 2021) conducted an analysis of the effects of concurrent usage of conventional and alternative energy sources on economic decarbonization in the US transportation industry. The estimated decoupling score highlights the fact that while improving energy efficiency helps to protect the environment, it is insufficient to decarbonize the economy. The most accurate measure of environmental contamination is thought to be carbon emissions (Wang & Zhang, 2021).

However, a lot of other indicators have also been chosen by academics. For instance, (Mrabet, 2017)) evaluated the sustainability of economic development using the environmental footprint (EF2017) measure. According to studies, the environmental footprint is a stronger indication of possible environmental effects than carbon emissions. Pollutant discharge fees were creatively used by Ji et al., (2021) as an indicator to measure the degradation and used it to analyze the decoupling of the economic and the environment. A strong to weak decoupling relationship would also occur. This finding is supported by Zhang et al., research of the Yangtze River Economic Belt (2020). Additionally, (Yu et al., n.d.) observed an absolute decoupling between air pollution and economic growth after accounting for some common air pollution indicators (sulfur dioxide, soot, wastewater, and solid waste emissions). Additionally, PM2.5 is frequently employed as a gauge for environmental pressure (Wu et al., 2022).

Therefore, it is apparent from confusing findings from the aforementioned studies that the validity of the EKC hypothesis is not guaranteed. Rather, it depends largely on the macroeconomic variables, energy consumption in particular, that are controlled for within the analysis. Hence, this paper makes a different attempt to bridge the gap in the EKC literature in this regard.

MATERIALS AND METHODS

This work concludes the outcome of economic growth, energy consumption and industrial sector for different harmful pollutants (CO_2, CO, NO_x, SO_2 and PM_{10}) for checking the presence of EKC in Pakistan. The model for these elements can be recognized as follows.T The empirical work of Begum describes the Cobb-Douglas function (Copeland & Taylor, 1994b). Which is the combined production function and the constant returns to scale and can be written as:

$$Yt = f(Kt, ALt) \ldots\ldots\ldots (1)$$

In equation '1', 'Yt' represents the economy and K_t, AL_t denotes the capital and active labour severally. Therefore, the pollution is normally recognized to the human actions, and it is perceived that the number of persons poisons the surroundings by the economic and other various activities, so the function of these emissions can be stated as

$$\text{Total Pollution } (Pt) = v[F(Yt)] \ldots\ldots (2)$$

where v shows the rate at which the production occurs proceed the harmful discharge. The capital measures are not responsible for the emissions, however for the production energy consumption is accountable for these pollutants. So, new equation will be written as

$K = Ke + Kn$ ……. (3)

The Ke and Kn represent the capital emissions and emissions free capital respectively. The capital's energy consumption is included to form emissions function expressed as

$Pt = \theta Ke(Y)$……. (4)

Moreover, it is highlighted that different mankind actions are rising the considerations of pollution in the atmosphere, so there are some additional variables like the industrial manufacturing and energy consumption to be assimilated in this manuscript. This study prolongs the previous work by adding the different dependent and independent variables. Also, it is described that manufacturing development may cause a growth, but it can also create environmental deficiency and industrial contamination (Zafar et al., 2020).

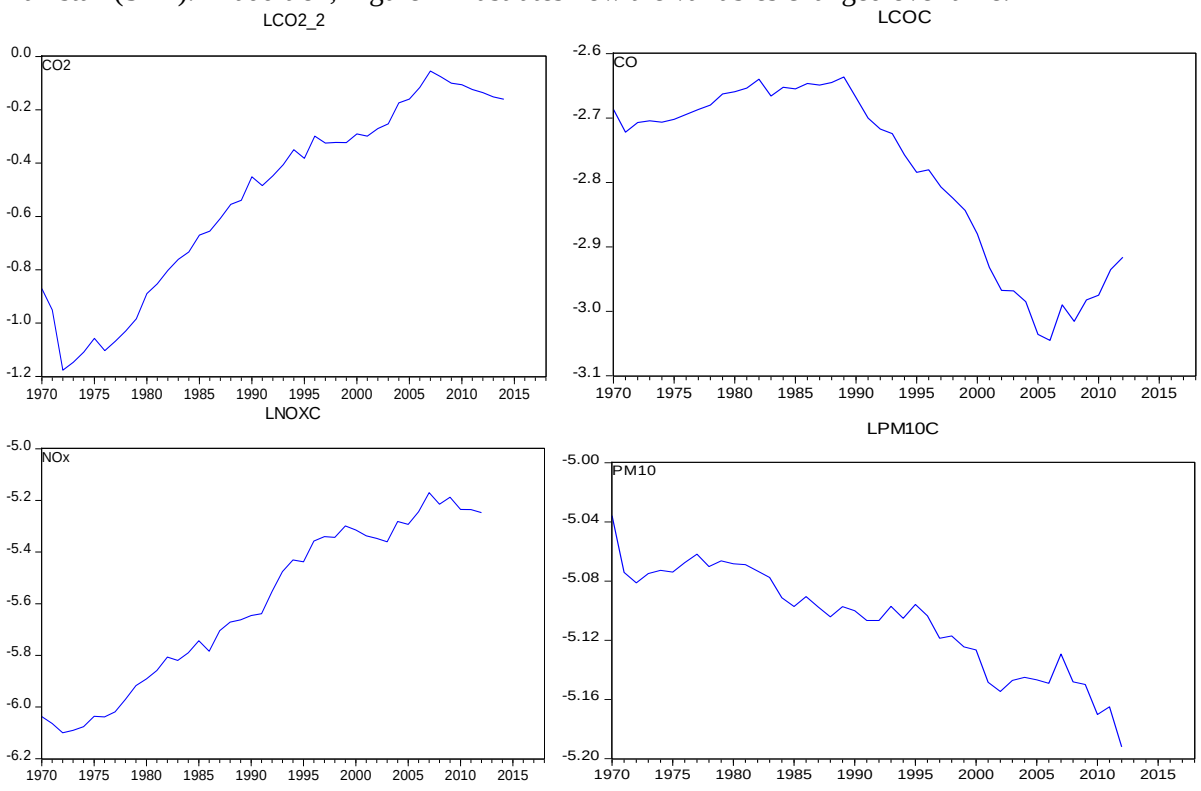
The variables used in this research can be expressed as,

$\ln Pt = \alpha_0 + \alpha_1 \ln EC_t + \alpha_2 \ln GDP_t + \alpha_3 \ln IND_t + \varepsilon_t$……. (5)

The occurrence of the EKC is established by taking the squared term of GDP. The strength of EKC will clear that whether the progress of the Pakistan's economy is the cost of environmental reputation or not. Thus, for EKC the equation '5' can be written as

$\ln Pt = \delta_o + \delta_1 \ln EC_t + \delta_2 \ln GDP_t + \delta_3 \ln(GDP)_t^2 + \delta_3 \ln IND_t + \varepsilon_t$……. (6)

In the above equation, the different emissions (Pt) characterize the environmental pollution in metric tons per capita, the energy consumption is presented by EC_t in kg of oil equivalent per capita, GDP_t shows the real GDP per capita, and the $(GDP)^2_t$ is used to observe the existence of EKC. The minus sign is predictable for δ_3. The inverted U-shaped form of EKC shows that per capita emissions rise with the growth in per capita income up to a certain point and after that the level of pollution is started to decline. If δ_3 is statistically insignificant, then emissions and income will rise continuously. The industrial improvement of the single state is joined with assets to GDP%. And the most important, the use of energy is vibrant in the industrial manufacturing section. The data for this research was calculated from the World Development Indicators (WDI) and Statistics Department of Pakistan (SDP). In addition, Figure 1 illustrates how the variables changed over time.



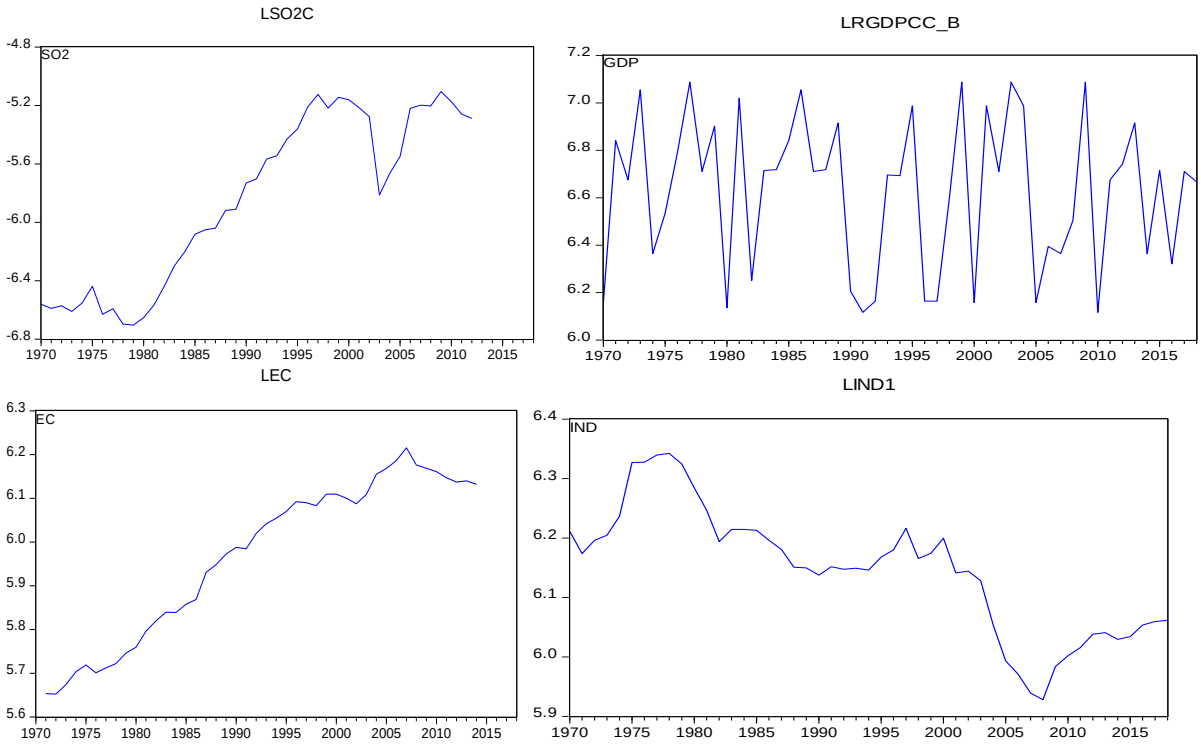


Fig 1. Plots of all variables

Source: Research finding

From the above concept, the α_0, α_1 and α_2 and will be having positive sign, as the use of more energy and big economic growth will increase the pollution. The expected value of α_3 can be either positive or negative considering the development level of energy and industrial factors. If an industrial section can examine the environmental quality, then a country might be more ecofriendly. But the main problem in Pakistan, the stockholders, participants, and other investors care about maximum profit and they do not pay attention about the environment. So, it is also expected that progress of industrial region might be useful for the appreciation in environmental contamination (Fodha, & Zaghdoud, 2010; Lotfalipour et al., 2010)

This work used the Autoregressive Distributed Lag (ARDL) bounds testing technique to cointegration by Pesaran, Shin, and Smith (2001) to determine the long run relationship between all the variables of this investigation (Frankel & Rose, 2005). This method is greater to the other cointegration approaches in many ways. As the variables are mixed at I(0) and I(1) by conducting unit root test. Before this test, we calculated the descriptive analysis. Below table 1 contains summary statistics for included variables.

Table No. 1. Summary statistics for the variable.

	LCO_2	**LCO**	**LNO_X**	**LPM_{10}**	**LSO_2**	**LGDP**	**LIND**	**LEC**
Mean	-0.5294	-2.7834	-5.6062	-5.1067	-5.8436	6.6139	6.1464	5.9689
Median	-0.4478	-2.7172	-5.6385	-5.1000	-5.7314	6.6764	6.1516	6.0304
Maximum	-0.0545	-2.6364	-5.1696	-5.0358	-5.1047	7.0872	6.3421	6.2154
Minimum	-1.1764	-3.0450	-6.0998	-5.1920	-6.7044	6.1169	5.9279	5.6524
Std. Dev	0.3559	0.1361	0.3131	0.0354	0.5829	0.2842	0.1063	0.1803
Skewness	-0.4004	-0.6401	-0.1936	-0.3923	-0.1910	-0.2942	-0.131	-0.432
Kurtosis	1.7832	1.8418	1.5506	2.3848	1.4468	1.9420	2.4372	1.6999

J-B(Prob.)	3.97(0.13)	5.33(0.06)	4.03(0.13)	1.78(0.41)	4.58(0.10)	2.99(0.22)	0.78(0.67)	4.46(0.10)
Observations	45	43	43	43	43	49	49	44

Source: Research finding

The unit root test is used to check the stationary level of data. This method is consisting of Dickey-Fuller (ADF) test and Phillips-Perron (PP) test for this purpose. The results of unit root test are presented in Table 2. So, after having result the ARDL method is applicable here. The long run and short run analysis can be test by this approach. In this model, the selection of suitable lag makes no endogeneity.

Table No. 2 Unit root test.

	Intercept		**Intercept +Trend**	
Variables	**Level**	**1st difference**	**Level**	**1st difference**
ADF				
LCO	1.5948[0.4763]	4.7935**[0.0003]	3.1484[0.1102]	4.9941**[0.0012]
LCO_2	1.5501[0.4999]	8.0557**[0.0000]	1.1433[0.9105]	8.4020**[0.0000]
LNO_x	1.0443[0.7285]	6.2332**[0.0000]	0.4806[0.9807]	6.4250**[0.0000]
LPM_{10}	3.4866**[0.0124]	3.58085**[0.0177]	0.9453[0.9998]	7.9498**[0.0000]
LSO_2	0.8229[0.8021]	5.7890**[0.0000]	1.3678[0.8557]	5.7277**[0.0001]
LGDP	0.6761**[0.0000]	1.8771**[0.0004]		
$LGDP^2$	2.5342**[0.0000]	3.9654**[0.0000]		
LEC	2.1110[0.2415]	5.0852**[0.0001]	0.3495[0.9983]	5.1179**[0.0001]
LIND	1.3000[0.6222]	6.1888**[0.0000]	3.0003[0.1428]	6.1651**[0.0000]
PP				
LCO	1.3514[0.5966]	5.1190**[0.0001]	1.5410[0.7989]	.2570**[0.0006]
LCO_2	1.7644[0.3933]	7.9820**[0.0000]	1.0054[0.9336]	8.4196**[0.0000]
LNO_x	0.9920[0.7475]	6.2582**[0.0000]	0.8010[0.9574]	6.4228**[0.0000]
LPM_{10}	1.9004[0.3290]	6.4471**[0.0000]	0.7018[0.9995]	8.4803**[0.0000]
LSO_2	0.8267[0.8021]	5.8110**[0.0000]	1.4913[0.8169]	5.7827**[0.0001]
LGDP	0.1366**[0.0000]	1.8754**[0.0003]		
$LGDP^2$	0.3589**[0.0000]	3.4578**[0.0000]		
LEC	1.9862[0.2916]	5.1103**[0.0001]	0.2426[0.9976]	5.7686**[0.0001]
LIND	1.3499[0.5987]	6.4886**[0.0000]	3.0452[0.1311]	6.5515** [0.0000]

Source: Research finding

Note: ** represents the significance level at 5%

To identify the presence of long run relationship, the study conducts the ARDL method and applied the OLS method for valuation of Eq. (3) as

$$\Delta \ln Pt = \lambda_1 \ln Pt_{2t-i} + \lambda_2 \ln EC_{t-i} + \lambda 3 \ln GDP_{t-i} + \lambda_4 \ln (GDP)^2_{t-i} + \lambda 5 \ln IND_{t-i} + \beta_0 + \sum^{P}_{i=1} \beta_1 ik \Delta \ln Pt_{2t-i} + \sum^{P}_{i=0} \beta 2 \Delta \ln EC_{t-i} + \sum^{P}_{i=0} \beta 3 \Delta \ln GDP_{t-i} + \sum^{P}_{i=0} \beta_4 \Delta \ln (GDP)^2_{t-i} + \sum^{P}_{i=0} \beta 5 \Delta \ln IND_{t-i} + \varepsilon t \ldots\ldots (7)$$

The above equation is for both analyses. The occurrence of the long run relationship is scrutinized through the F statistics by consideration the null hypothesis of no co-integration, Ho = $\lambda_1=\lambda_2=\lambda_3=\lambda_4=\lambda_5= 0$. Whereas the alternative hypothesis assumes that the variables are not equal to zero. Schwartz–Bayesian Criteria (SBC) and Akaike Information Criteria (AIC) is for choosing the

best lag length for the variables. The ARDL method measured the number of regressions as (P + 1) K, where 'P' symbolizes the lags, and the K represents the variables in our model. After having long run examination, the error correction equation is given as

$$\Delta \ln Pt = \ln Pt = \beta_0 + \sum^{P}_{i=1} \beta_1 ik \Delta \ln Pt_{2t-i} + \sum^{P}_{i=1} \beta 2 \Delta \ln EC_{t-i} + \sum^{P}_{i=1} \beta 3 \Delta \ln GDP_{t-i} + \sum^{P}_{i=1} \beta_4 \Delta \ln (GDP)^2_{t-i} + \sum^{P}_{i=1} \beta 5 \Delta \ln IND_{t-i} + \theta ECT_{t-I} + \varepsilon t \ldots\ldots (8)$$

In above equation the error term represents the equilibrium of long run after the shock in short run. In the end, this research also applied the CUSUM and square of CUSUM test for testing the stability of CO_2, CO and SO_2. The regression model will be stable, if the value of statistics is within the 5% significance level. (Figures 2, 3 and 4)

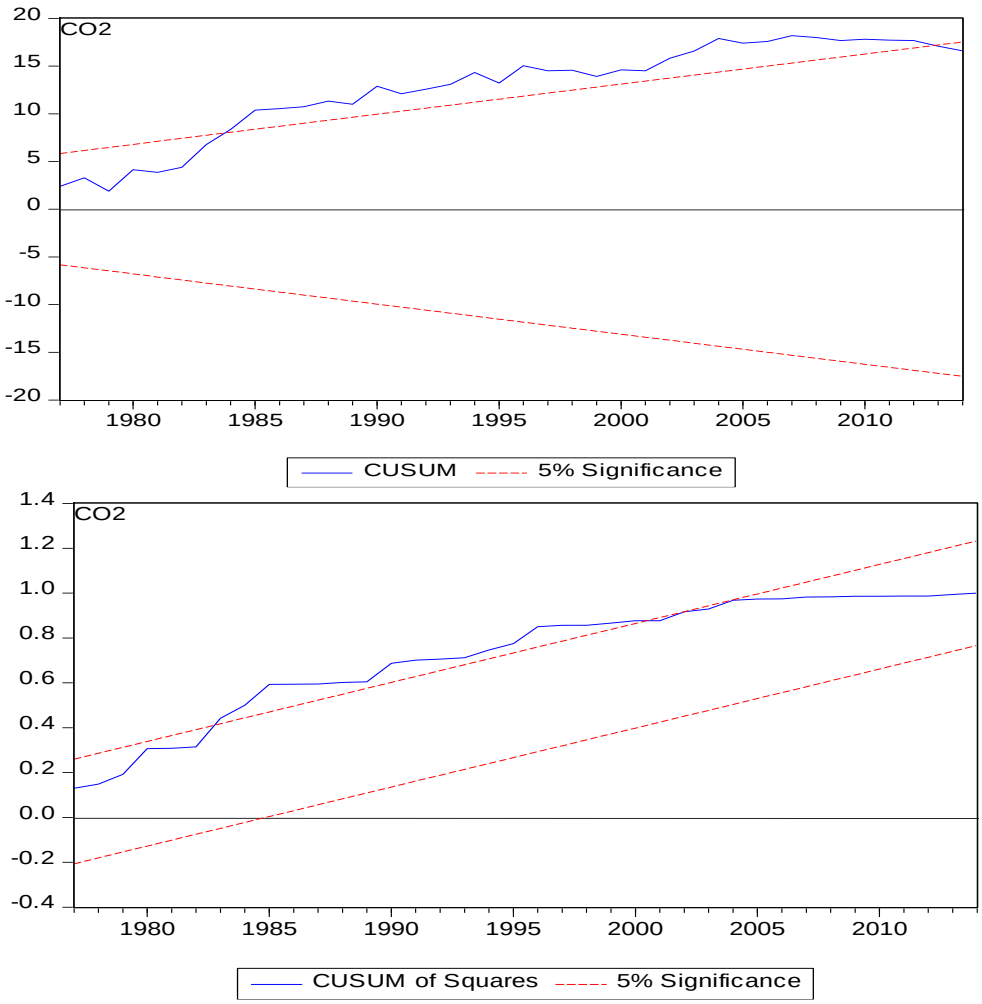


Figure 2. Plots of cumulative sum of recursive residuals for CO_2

Source: Research finding

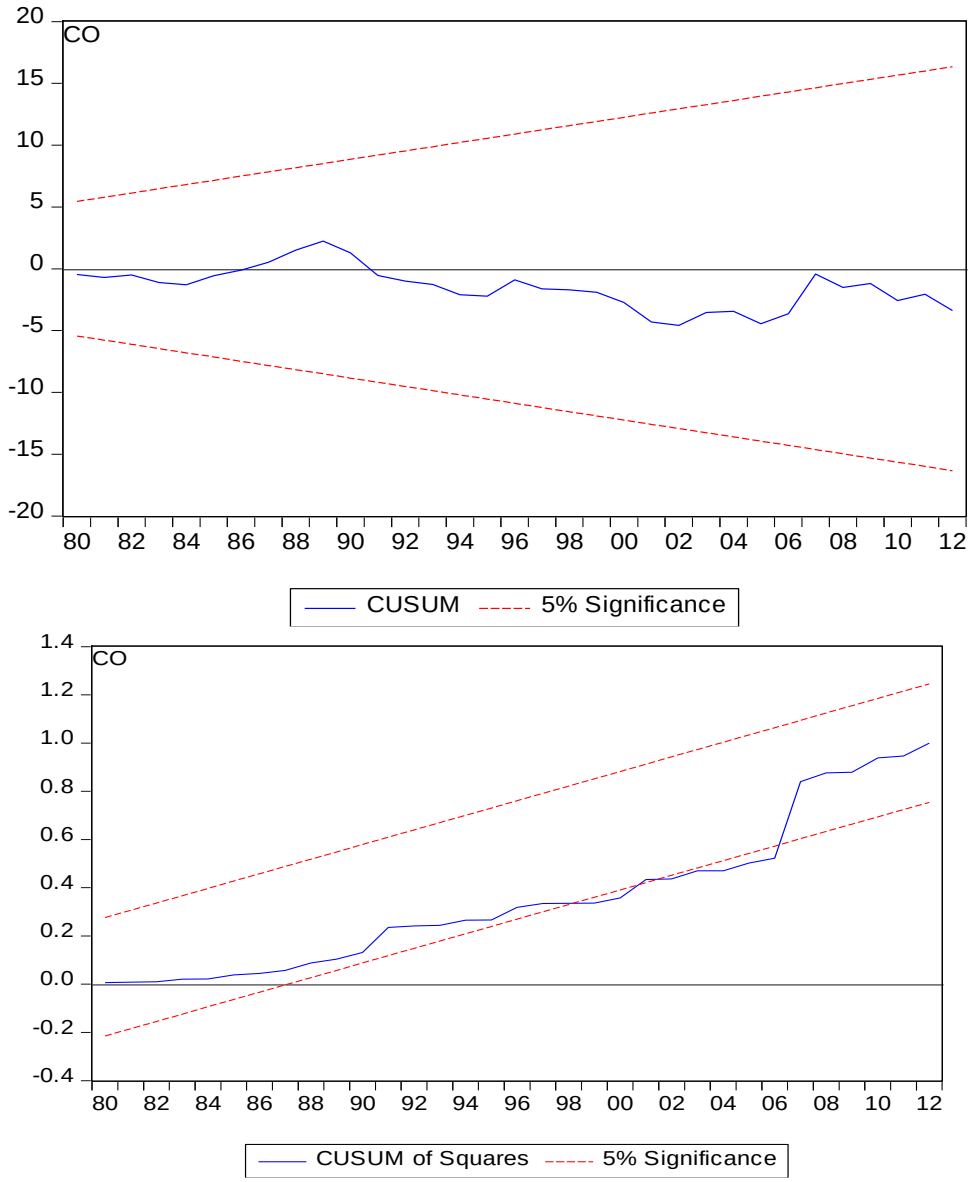
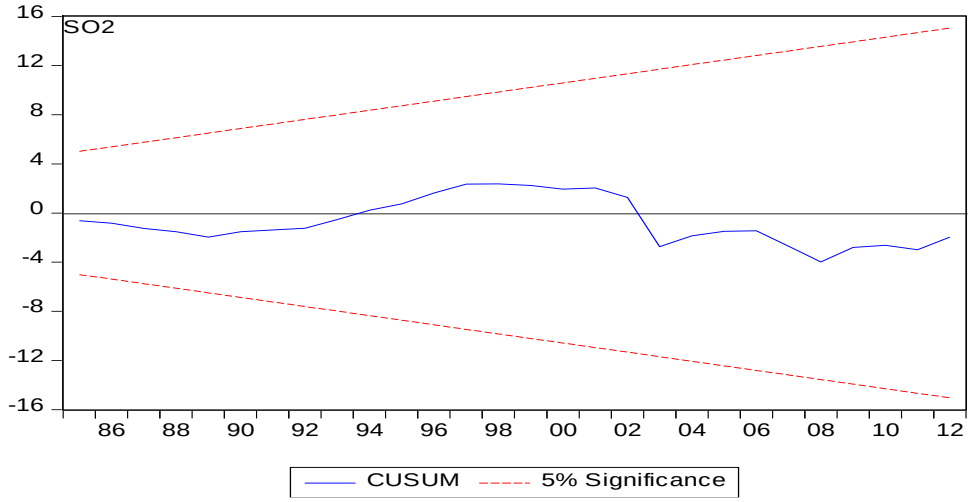


Figure 3. Plots of cumulative sum of recursive residuals for CO
Source: Research finding



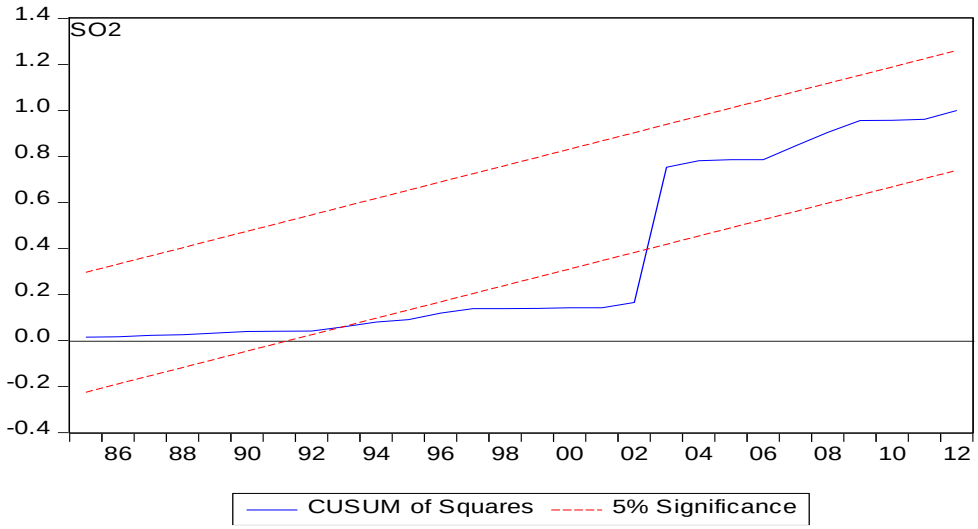


Figure 4. Plots of cumulative sum of recursive residuals for SO_2
Source: Research finding

RESULTS AND DISCUSSION

The empirical examination of time series data to be stationary is to choose which cointegration test is most applicable for best applicable solution. As the variables are mixed at level and first difference. So, it proves the use of ARDL method will be suitable for this research. For finding the cointegration the Wald test is conducted and the calculated values of F-statistics for three pollutants (CO_2, CO and SO_2) are greater than the critical values of upper bound. So, for these three pollutants the long run and short run exist (Table 3). However, for other two pollutants (NOx and PM_{10}) the cointegration does not exist as the F-statistics is smaller than the upper bond.

Table No. 3 ARDL result of Co-integration.

Variables	AIC lags	F-statistics	Results
LCO_2	2	3.5768	Co- integration
LCO	2	3.5511	Co-integration
LSO_2	2	10.01171	Co-integration
LNO_x	2	2.9669	No Co-integration
LPM_{10}	2	1.1760	No Co-integration

Source: Research finding

ARDL long and short run result for CO_2

As from the table 3, it is proved that the variables (CO_2, CO, and SO_2) have cointegration but NO_x and PM_{10} have not cointegration. The long run and short run analysis of ARDL method are explained in table 4,5 and 6 for the CO_2, CO and SO_2 emissions respectively. In table 4. The results show that in long run the economic growth has a positive and significant effect on CO_2 emissions, which means by increasing the 1% GDP, the CO_2 will be high 5.66% in Pakistan. Whereas the square of GDP has a negative sign which proves the existence of EKC for CO_2 in long run estimation. It means by growing the economic growth the harmful CO_2 emission will be decrease with time. If the square of GDP will be improved 1 percent, then the CO_2 emissions will be decrease by 0.39 percent. This result is in line with (Begum et al., 2015; Gonzalo, & Lee, 1998).

Moreover, the effect of energy consumption is significant and positive. Which means, if there is 1% intensification in energy consumption then the emissions will also rise by 1.09%. By using extra energy, the harmful emissions will be more in long run. This outcome is like the work of (Salim et al., 2019)**.** Now, the effect of industrialization is negative and insignificant. The 1% rise in industrial level can reduce the emissions by 0.25% in long run. But the insignificant impact tells us, the country should give more concentration to industry in developing the friendly environmental projects. Whereas, moving towards short run analysis, the results are little bit varies. As in this case the value of GDP is positive but insignificant. Which means 0.10% rise in CO2 emissions is due to 1% increase in GDP in short run. Secondly, in short run analysis, the EKC does not hold for CO_2 emissions. From the table 4, it can be seen the sign of $(GDP)^2$ is positive and insignificant too.

Meaning that, the pollution will be more by increasing GDP and square of GDP. If there is an upsurge of 1% in $(GDP)^2$ the critical CO_2 rises 0.74%. However, the insignificancy of the variables shows the country needs to be more progressive in short run for achieving the less contaminated results. This is the same as the empirically work of (Coondoo, & Dinda, 2002)**.**

Additionally, the upshots for energy consumption are similar to long run results. As the energy consumption is positive and significant in short run for Pakistan. Both CO_2 emissions and energy consumption have directly proportional relationship. Depending on 1% rise in energy consumption will lead to 1.50% increase in CO_2 emissions. Following this, the influence of industrial sector is negative and insignificant. So, from the presented digits the 1 % growth in industrial sector can lessen the CO_2 pollution by 0.04% in short run. Lastly, the error correction term (RESID01) is significant with the positive sign and the rate of 0.87% forms the presence of the long-term relation among all the variables of this research. This term tells that any uncertainty in the CO_2 productions will be collected to the equilibrium point in the long run with a rush of 0.87%.

Table No. 4 Long run and Short run ARDL analysis

Dependent variable: CO_2

Variables	Coefficients	t-statistics	P-value
Long run coefficients			
LGDP	5.6612	2.6708	0.0111**
LGDP^2	-0.3928	-2.4387	0.0195**
LEC	1.0965	5.1136	0.0000**
LIND	-0.2583	-1.7471	0.0887
C	-25.6866	-4.0475	0.0002**
Short run coefficients			
DLGDP	0.1093	0.7597	0.4531
DLGDP^2	0.7467	0.2596	0.7968
DLEC	1.5042	14.5829	0.0000**
DLIND	-0.0428	-1.0263	0.3126
RESID01	0.8722	10.2850	0.0000**
C	-0.0034	1.8765	0.0500**

Source: Research finding

ARDL long and short run results for CO

The empirical results for carbon monoxide (CO) emissions are expressed in table 5. The consequences illustrate that in long run the economic growth has a negative and insignificant impact on CO emissions, which means by increasing the 1% GDP, the CO will be decline 19.86% in Pakistan. On the contrary, the square of GDP has a positive sign but has insignificant value, which verifies there is no EKC for CO emissions in long run valuation for Pakistan. It exposes by growing the economic growth the destructive CO will be more with time. If the square of GDP will be enhanced 1% then the CO emissions will rise by 1.90%. This result is in line with (Cropper, & Griffiths, 1994). This study also includes the conclusion of energy consumption is negative and insignificant. Which means, if there is 1% appreciation in energy consumption then the emissions go down by 7.21%. By using the extra energy, the harmful emissions will be less in long run. Therefore, in case of CO pollution, the Pakistan has better results considering the economy and energy consumption. This study further completes the effects of industrial development is positive and insignificant. The 1% rise in industrial level can rise the CO emissions by 1.07% in long run. But the insignificant impact tells us, the country should give more awareness to manufacturing in emerging the sociable environmental tasks.

On the other hand, the short run results are almost same, but the P-values are changed for some variables. As in this case the value of GDP is positive but insignificant. Which means 1% growth in an economy can cause 0.94% rise in the level of CO emissions in short run. Next, in short run analysis the EKC for CO pollution is again not valid. The value of $(GDP)^2$ is positive and insignificant. It makes sense that the pollution will be more by collecting both GDP and its square. If there is an expansion of 1% in $(GDP)^2$ the dangerous CO emissions rises 7.18%. Though, the insignificant level of the variables displays the country needs to be further advanced in short run for attaining the less polluted results. As well as the effects for energy consumption are negative and significant in short run results. This impact shows the inverse relation between pollution and energy

consumption. Provided that the 1% rise in energy consumption will decrease 0.92% in CO emissions. This result is same as the empirical work of (Carson et al., 1997)**.** Following this, this research also concludes the influence of industrial area is positive and significant. Which means the pollution will be high by having more industries. Considering the numeric values, 1% growth in manufacturing leads to 0.43% in CO emissions. Lastly, the error correction term is significant with the positive sign and the rate of 1.83% forms the existence of the long-term association between all the elements of this research.

Table No. 5 Long run and Short run ARDL analysis

Dependent variable: CO

Variables	Coefficients	t-statistics	P-value
Long run coefficients			
LGDP	-19.8607	-0.6150	0.5427
LGDP^2	1.9029	0.6940	0.4925
LEC	-7.2111	-1.4746	0.1498
LIND	1.0744	0.9404	0.3538
C	81.7627	0.7109	0.4821
Short run coefficients			
DLGDP	0.9419	1.9445	0.0616
DLGDP^2	7.1827	0.7636	0.4512
DLEC	-0.9278	-3.1620	0.0037**
DLIND	0.4308	3.0236	0.0052**
RESID02	1.8334	5.6524	0.0000**
C	-0.0158	-3.0619	0.0047**

Source: Research finding

ARDL long and short run results for SO_2

Table 6 explains the outcomes for Sulphur dioxide (SO_2). This table also includes the long run and short run outcomes. The first independent variable is GDP. It has positive and insignificant influence on SO_2 emissions, which describes the growing GDP can enhance the SO_2 emissions. As from the table it can be seen, the 1% increase in GDP can release the SO_2 pollution up to 15.81% in Pakistan. In the same way, the square of GDP has a negative sign which evidences the presence of EKC for SO_2 in long run assessment. It means the harmful emissions will be lower if country grows its economy. If this variable i.e. $(GDP)^2$ will be amended 1% then the SO_2 emissions will be decrease by 1.32%. These results have resemblance with (Ang, 2007)**.** In addition to this, the conclusion of energy consumption is significant and positive. If there is 1% rise in consumption of energy, then the SO_2 will also increase by 5.04%. By using more energy, the injurious discharges will be more in long run. This finding is in line with (Tisdell, & Tisdell, 2008).

Beside this, this study also describes the impact of industrialization is negative and insignificant. The 1% increase in industrial level reduces the toxic level by 0.69% in long run. Due to insignificant value, the host country must improve its industrial management. Likewise, this research also presents the short run coefficients, and the main results are almost identical. Which accomplishes, the economic condition of Pakistan should be improved quickly. As in this scenario, the coefficient of GDP is positive but significant. Which means in short run the SO_2 emissions will be increase 4.24% by increasing the 1% economy. Similarly, like long run estimations the EKC for SO_2 is also valid during short run for Pakistan. Table 6 shows, the negative sign with square of GDP but its impact is insignificant. Having said that, the contamination decreases as long as the country's GDP increases. If there is an increase of 1% in $(GDP)^2$ the hazardous SO_2 reduces 0.51%.

This manuscript also demonstrates the effects of energy consumption is parallel to long run results. As the energy consumption is positive and significant in short run for Pakistan. Both dependent (SO_2) and independent (EC) variables will move in same direction. As the 1% rise in energy consumption will enhance the pollution level by 2.34%. This result is in line with (Stern et al., 1998). Next, the result of industrial sector is positive and significant. So, from the calculated results, the 1 % growth in industrial area can enhance the SO_2 pollution by 1.16% in short run. Finally, the error correction term is significant and positive with coefficient value 0.11%. Which ensures the

existence of long run relationship between the variables. With time, by developing the economic growth the host country can be pollution free.

Table No. 6. Long run and Short run ARDL analysis

Dependent variable: SO_2

Variables	Coefficients	t-statistics	P-value
Long run coefficients			
LGDP	15.8171	1.3679	0.1822
LGDP^2	-1.3295	-1.4521	0.0476**
LEC	5.0495	5.3165	0.0000**
LIND	-0.6913	-0.7379	0.4667
C	-78.0963	-2.3411	0.0266**
Short run coefficients			
DLGDP	4.2458	4.7422	0.0001**
DLGDP^2	-0.5177	-0.0455	0.0064**
DLEC	2.3440	5.0760	0.0000**
DLIND	1.1616	2.9941	0.0067**
RESID03	-0.1148	2.7202	0.0125**
C	-0.0779	-4.6935	0.0001**

Source: Research finding

CONCLUSIONS AND POLICY SUGGESTIONS

This research explores the EKC theory and determined the link among harmful emissions versus three variables (economic growth, energy consumption, and industrialization) by means of Auto Regressive Distributed Lag (ARDL) procedure for Pakistan from the year 1970 to 2018 over time series analysis. The valuation was founded on both short and long run properties.

The solution reveals that the long run and short run existences are founded for CO_2, CO and SO_2 but not for other two pollutants (NO_x and PM_{10}). And the inverted U shaped is occurred in case of CO_2 only for long run estimation but for SO_2 emissions, it is verified in both long and short run. But then for CO the occurrence of EKC does not happen. So, it is established that for major harmful emissions (CO_2), the EKC is a long run occurrence in case of Pakistan and most fascinatingly with all other descriptive variables like energy consumption and industrialization are also supplier to environmental destruction in Pakistan. The industry helps to recover the situation in short-run path first.

To reduce the pollution deprived of obstructing economic growth in Pakistan, the study highly advises the market rule, adoption advance study. The harmful emissions mostly happen in the industrial and as well automobiles actions. The free market is the vital factor to improve this pollution. The neoclassical theory (or Keynesian theory) of economics determines that the value of better implications for the host country. This model, nevertheless, is only built on making profit in fiscal terms (Begum et al., 2015; Jalil, & Mahmud, 2009).We can protect our environment, helping private sector creation also hangs the environment. No industry should drive into creation without a comprehensive Environmental Impact Assessment (EIA) (Bradford et al., 2005b).

Highly developed technology from the advanced countries must be presented in both fabrication and waste handling. Tax outline and law implementation have established to be actual in the cases of some fixed pollutants in altered. Furthermore, Political power is an extra central issue that energies both the economy and the environment (Vehmas, 2005). All of these variations in the policy of Pakistan are projected to hypothesis the channel over EKC. Just as essentially, the national environment policy, energy policy, forest policy and industrial policy should be synchronized and examined strongly to reach all these benefits.

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