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Impact of Environmental Degradation and Energy Consumption on Growth: An Empirical Analysis

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Abstract: Pakistan's status as a nation like many developing economies, environmental degradation, and accelerating growth, investigates the impact of environmental degradation along with energy consumption on growth for policy implications. To discover the short and long period associations in these factors, the ARDL approach is used the data from 1981 to 2016. Estimates of bounds test and the value of ECM term validate the presence of significant short and long-run associations amongst these variables i.e., environmental degradation exerts negative impact on growth, whereas, energy consumption, capital formation, and effective labour force have positive effects on growth in Pakistan. Results of the study propose that authorities should adopt such types of policies that aim at increasing energy consumption, raising capital formation, and lessening carbon dioxide emissions so that environmental deterioration could be controlled and accelerated economic growth could be achieved in Pakistan. Findings of this study may be imperative for researchers, authorities and decision makers in energy policy, environmental policy and growth..

Keywords: Environmental degradation, Energy consumption, Growth, Auto regressive distributed lag

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INTRODUCTION

The interaction between human activities and environmental degradation can be drawn from the ideas of Malthusian (1798) who explained that population growth will ultimately cross the limit of resources without technological progress. Today global warming and climatic changes as severe environmental problems of the world are possibly due to the population growth as well as the development of technology, as carbon dioxide (CO_2) as a principal factor of the greenhouse effect, is responsible for infuriating environmental issues (Ozcan, 2013). The global environment has been affected by the human population and its activities at an extraordinary limit (Spangenberg, 2007). Theory of Environmental Kuznets Curve (EKC) analyses the consequences of growth on environmental status. There exist a bulk of studies which has examined EKC for different economies. Given policy developments, resolving the matter of the link between economic growth and the environment seems of meticulous importance.

Iwata et al. (2009) examined the environmental Kuznets curve for the case of France. Due to international trade and energy consumption, environmental degradation might be increased. Objective of the study was empirical testing of EKC hypothesis in France and it was done by using ARDL methodology to co-integration. Findings have indicated that impact of CO_2 emissions was adverse in both the short and long periods, and results of trade have shown that it was not significant. One way causality from income to CO_2 emissions has implied that even though economic growth causes to increased CO_2 emissions, but reducing them did not detain the development. The study has provided the proof of significant role of energy to lessen environmental degradation. Findings of the study

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claimed the evidence of Environmental Kuznet's Curve hypothesis in France. It was suggested that it was essential to that nuclear energy generation will require to escape any mishap that cause destruction to the environment.

Saboori et al. (2012) inspected the association between CO_2 and development in Indonesia based on Environmental Kuznets Curve from 1970 to 2007 by using trade-openness and energy consumption. Co-integration has been checked by applying the ARDL method. Findings indicated the U-shape relationship between environmental degradation and growth which has authenticated that environmental degradation declined at starting level of the growth, and increased with the higher level of growth.

Therefore, findings have refuted the EKC proposition. The elasticity of environmental degradation for energy consumption was found positive and encouraging. Trade openness has exerted encouraging and considerable in the long period, it was adverse and negligible during a short period. The coefficient of ECM (-1) has supported co-integration.

Ozcan (2013) explored the connection between environment, energy consumption, and growth in the 12 Middle East economies, to confirm the EKC. The results presented the existence which was contrary to the environmental Kuznets curve. Five Middle East countries exposed the U-shaped EKC, whereas, a reversed U-shape link was present in three Middle East economies, whereas, the remaining four economies showed no causality between income and environmental depletion. The one-way casual effect was present from development to energy consumption in the short-run, whereas, the one-way casual effect from energy consumption and growth to environmental depletion was discovered in the long period.

Baek and Kim (2013) scrutinized the effects of growth on the environment for Korea for energy consumption, fossil fuel, and electricity in the co-integration model. EKC was confirmed for Korea i.e., growth has played a favorable part in influencing the environment. Findings exhibited that nuclear energy was helpful for the environmental deterioration in a short period and long period, while, fossils fuel, electricity production, and energy consumption had destructive impacts on environmental conditions.

Lau et al. (2014) scrutinized EKC for carbon secretions in Malaysia by employing Bounds testing and Granger Causality approaches for the period 1970 to 2008. Reversed U-shaped association between growth and CO_2 secretion has existed for short period and a long period in Malaysia.

Jula et al. (2015) scrutinized the long-term association between growth and CO_2 emission from 1960 to 2010 and found a robust long-run association. A reversed N-shaped association between CO_2 emissions and growth was present in long term. The results were identical to the Environmental Kuznets Curve (EKC) and validate the EKC theory for Romania. The results have supported the inverse N-shaped EKC and it was worth mentioning that the econometric results did not clarify the reasons that have caused to inverse N-shaped association. Findings of the study have indicated that some imperative factors i.e., the structure of the economy, the share of imports in GDP that have caused high CO_2 emissions in the process of production, and the changes in the environmental legislature in Romania had an important role in setting the shape and future evolution of the association amongst income and environmental degradation.

Nasreen et al. (2017) studied the relationship amid economic growth, CO_2 emission, energy consumption and financial stability over the period 1980-2012 and used the Granger causality and cointegration approach. That showed the improvement in the quality of environmental due to the financial stability while the qualities of environment declines due to the energy use population and economic growth which indicated that in Pakistan and Sri Lanka, unidirectional causality running to CO_2 emissions from financial stability.

Danlami et al. (2018) purposed to survey the link amongst economic growth, capital formation, FDI, and CO_2 emissions in the LMI and Middle East North Africa (MENA) nations during the period of 1980-2011. Two single autoregressive distributed lag (ARDL) models were assessed for the both LMI and MENA countries. Moreover, a fully modified OLS (FMOLD) was valued for the two regions over the same period. Concluded with results that there is positive significant impact of CO_2 emission for the lower-middle income nations in the long run while in the short run FDI were positively related to CO_2 emissions and gross capital formation had a negative impact on CO_2 emissions in short run over the same period. In the MENA nations there is a positive relationship between gross capital formation and CO_2 emission in the short run and in the long run and from GDP all other variables had significant positive impact on CO_2 emissions. Examiner mentioned the adoption of green technology by FDI firms.

Haseeb et al. (2018) investigated the role of renewable energy consumption to influenced economic well-being in Malaysia. The researcher used the period of 1980-2016.This study applies ARDL method. The study used

renewable energy and economic growth as a proxy to examine the long run connection between renewable energy and economic well-being. The results of ARDL bound testing approach confirmed the valid long-term connection among renewable energy and economic well-being in Malaysia. Moreover, the results indicated that renewable energy has significant and positive impact on economic well-being in short and long run. It is therefore recommended that the policymakers are required to focus on the green energy generation sector by increasing renewable energy production from the existing sources.

Safdar et al. (2019) explored the influence of environmental degradation and energy consumption on economic growth in emerging states. Panel-ARDL model was an appropriate system to estimate the long run as well as short run affairs due to mixed order of integration. The homogeneous panel causality test was also used to invent the relationship concerning the energy consumption and environmental degradation on macroeconomic variables. The marks stated that energy consumption had appositive and statistically significant effect on growth in three panels LMIC, UMIC, and in ASDCs except LICs where it has negative but significant effect on economic growth. The environmental degradation had negative impression on economic growth in all panels. The proposition fulfills the all objectives of this study and feedback theory showed the causal relationship between energy consumption and environmental degradation on macroeconomic variables.

Rehman and Ahmed (2019) tried to confirm that the interconnection amongst the gross capital formation and carbon dioxide emission in Pakistan during the period 1980-2016 by hired Non-linear Auto Regressive Distributed Lag (NARDL) model completed with the environmental Kuznets hypothesis and controlled for the coal and oil consumption variables as a potential factors of CO_2 emissions. The outcomes confirmed that the existence of an asymmetric effect of GCF shocks on CO_2 emissions both in the short and long term. Furthermore, the empirical findings also suggested that coal and oil consumption have a important contribution to CO_2 emissions both in the short and long terms and also significantly maintained the presence of EKC hypothesis.

Muhammad (2019) scrutinized the energy consumption, CO_2 emissions and economic growth in developed, emerging and Middle East and North Africa economies. Objective of research was to examine the effect of economic growth and CO_2 emissions on each other. SUR model by using GMM and System GMM was employed on panel data from 68 countries over the period 2001 to 2017. Empirical results exhibited that in developed and emerging economies, increased energy consumption has led to increased economic growth, but exceptional for MENA countries due to increased CO_2 emissions. Policy makers of these countries were required to adopt such type of guidelines that could focus on environmental friendly techniques to reduce CO_2 emissions.

Munir et al. (2020) re-evaluated association among CO_2 excretion, energy consumption and economic growth in five Association of Southeast Asian Nations for the period 1980 to 2016. Granger causality was applied to examine the direction of the association among the variables. Outcomes of the study revealed unidirectional causality for GDP to CO_2 excretion for Malaysia, Philippines Singapore and Thailand,.

Pejovic et al. (2021) examined the associations amongst economic growth, energy consumption and CO_2 excretion for twenty seven countries of European Union and the Western Balkans from 2008 to 2018. Objective of the study was to investigating the associations amongst economic growth, energy consumption and CO_2 excretion in European Union and the Western Balkans and it was done by applying Panel VAR model, GMM, and System GMM. Results have also shown that bidirectional and neutrality causality form GDP to CO_2 excretion and GDP to energy consumption. Findings have claimed the association among all the variables and reported that variations in GDP were the main reasons for variations in CO_2 excretion. It was suggested that by increasing consumption from renewable sources might lead to drop in CO_2 excretion which will helpful desirable environmental targets.

Most of the literature explained that CO_2 emissions would likely to lead to changes in growth (Saboori et al., 2012). Energy was main factor for growth and it has become an imperative for scrutinizing the interaction amid these variables. Many studies have discovered associations amongst growth, CO_2 and energy consumption. Arouri et al. (2012) analyzed association amongst energy consumptions, growth and CO_2 secretion for MENA and found positive impacts of CO_2 emission and energy consumption on growth. Pao and Tasi (2012) investigated the estimation of CO_2 emission, energy, and development in Brazil and claimed carbon dioxide exerted negative effects on economic development in MENA economies. Omri (2013) discovered the link among CO_2 emission, energy, and growth in MENA economies. It was reported that carbon dioxide has negative effects on gross national product in some countries whereas, converse results were also observed in other countries. The impacts of energy consumption on gross national product were positive across MENA countries. Cowan et al. (2014)

evaluated the causality link amongst consumption of electricity, growth and CO_2 emission for BRICS countries and reported heterogeneous results across the BRICS economies. It can be proposed that exploring association amid growth, CO_2 emission, and energy consumption becomes crucial for appropriate policy implications to protect the environment, combating the global warming, and guaranteeing sustainable growth. Review of literature reveals that some studies have claimed contradictory findings for different countries within the same study, some regions have claimed positive association among energy consumption, CO_2 emissions and economic growth, whereas, some regions have depicted negative association among these variables (Bashir, 2019; Munir, 2020; Pajovic, 2021). The literature is yet to provide a definitive conclusion on this relationship and Pakistan may be a good case study.

METHODOLOGY

Data

The objective of the study is to explore the impact of environmental degradation and energy on growth in Pakistan. Data from 1981 to 2016 was obtained from the WDI database (WDI, 2016) and the Economic Survey of Pakistan (various issues). In this study environment is measured by CO_2 emissions in (kt) (Bertinelli et al., 2012; Cowan et al., 2014; Lau et al., 2014, Ozcan 2013) have utilized CO_2 emissions to estimate the effect of environmental deteriorations). Energy consumption has been measured by (kt of oil equivalent) as utilized by the studies (i.e. Apergis and Payne, 2010; Omri, 2013; Wang et al., 2013) etc. Growth is measured by GDP annual growth (%) (see e.g. Baek and Kim, 2013; Cowan et al., 2014; Cherniwchan 2012; Nasreen and Anwar 2014).

Model

We have specified the following model:

$$\mathrm{GDP} = \mathrm{f}\left(\mathrm{CO}_2, \mathrm{ENC}, \mathrm{CPF}, \mathrm{ELF}\right) \tag{1}$$

Where,

- GDP = Annual GDP Growth Rate.
- CO_2 = CO_2 Emission in (kt).
- ENC = Energy Consumption in (kt).
- CPF = Capital Formation (% of GDP).
- ELF = Effective Labour Force (% total population).

Econometric transformation for the model is as:

$$\mathrm{GDP} = \alpha_0 + \alpha_1 \mathrm{CO}_2 + \alpha_2 \mathrm{ENC} + \alpha_3 \mathrm{CPF} + \alpha_4 \mathrm{ELF} + \varepsilon_{\mathrm{u}} \tag{2}$$

where, εt is stochastic disturbance term, 1, 2, 3 and 4 will capture the effects of CO_2 emissions, and energy consumption, capital formation and effective labour on growth in Pakistan.

Bounds testing approach

The bound testing approach ARDL is more appropriate and reliable for the studies with small sample sizes. Consequently, the issues related to the robustness of co-integration tests will be minimized by using the bounds test.

$$\Delta \mathrm{GDP}_{\mathrm{t}} = \alpha_0 + \sum_{i=0} \alpha_{1i} \Delta(\mathrm{GDP})_{\mathrm{t-j}} + \sum_{i=0} \alpha_{2i} \Delta\left(\mathrm{CO}_2\right)_{\mathrm{t-j}} + \sum_{i=0} \alpha_{3i} \Delta(\mathrm{ENC})_{\mathrm{t-j}} + \sum_{i=0} \alpha_{4i} \Delta(\mathrm{CPF})_{\mathrm{t-j}}$$
$$+ \sum_{i=0}^{k_3} \alpha_{5i} \Delta(\mathrm{ELF})_{t-i} + \beta_1 (\mathrm{GDP})_{\mathrm{t-1}} + \beta_2 \left(\mathrm{CO}_2\right)_{\mathrm{t-1}} + \beta_3 (\mathrm{ENC})_{\mathrm{t-1}} + \beta_4 (\mathrm{CPF})_{\mathrm{t-1}} + \beta_5 (\mathrm{ELF})_{\mathrm{t-1}} + \varepsilon_{\mathrm{t}} \tag{3}$$

In this model, we will use the lag of the first difference for the short period and the first lag for the long period. Null hypotheses will be assumed that all the coefficients of lagged regression are absent from the model.

Hypotheses for a general approach to economic growth and environment in the Bound test are as follows:

H0: Co-integration does not exist.

H1: Co-integration does exist.

The model is given in equation 3 will be used to detect the impact of environmental degradation and energy consumption on growth in Pakistan. The ARDL model for long-run coefficients ($\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$) of a general approach to the model of growth, environmental degradation, and consumption of energy is given as:

$$\Delta \mathrm{GDP_t} = \delta_0 + \sum_{i=0}^{k_1} \delta_{1\mathrm{j}} (\mathrm{GDP})_{\mathrm{t-j}} + \sum_{i=0}^{k_2} \delta_{2\mathrm{i}} \left(\mathrm{CO_2}\right)_{\mathrm{t-j}} + \sum_{i=0}^{k_\mathrm{j}} \delta_{3\mathrm{i}} (\mathrm{ENC})_{\mathrm{t-j}} + \sum_{i=0}^{k4} \delta_{4\mathrm{i}} (\mathrm{CPF})_{\mathrm{t-j}} + \sum_{i=0}^{k5} \delta_{5i} (\mathrm{ELF})_{\mathrm{t}i} + \mathrm{e_t} \tag{4}$$

After estimating the above model, we could discover short period coefficients of the selected model of the error correction. The value of the error term must be negative and statistically significant which will indicate that short-run association does exist. The short period error-correction for the general model is given as:

$$\Delta \mathrm{GDP}_t = \sigma_0 + \lambda (\mathrm{ECM})_{\mathrm{t-1}} + \sum_{i=0}^{k_1} \sigma_{1j} (\mathrm{GDP})_{t-i} + \sum_{i=0}^{k_2} \sigma_{2i} \left(\mathrm{CO_2}\right)_{\mathrm{t}-i} + \sum_{i=0}^{k_3} \sigma_{3i} (\mathrm{ENC})_{t-i} \sum_{i=0}^{k4} \sigma_{4i} (\mathrm{CPF})_{\mathrm{t-i}} + \sum_{i=0}^{k5} \sigma_{5\mathrm{i}} (\mathrm{ELF})_{t-i} + \varepsilon_\mathrm{s} \tag{5}$$

DISCUSSION ON ARDL RESULTS

ADF test will be used to detect stationary or non-stationary properties of data.

Table 1: Estimates of ADF Test

	Level			1st Difference		
Variable	*t*-statics	Critical value	Prob.	*t*-statics	Critical value	Prob.
CO_2	-1.888	-4.219	0.641	-7.000	-4.227	0.00
ENC	-1.204	-4.219	0.895	-3.549	-4.227	0.04
CPF	-1.317	-4.219	0.641	-6.283	-4.227	0.00
ELF	-1.628	-4.219	0.641	-5.117	-4.227	0.00
GDP	-3.986	-3.616	0.003	-9.866	-3.621	0.00

Table 2: Conclusion on unit root test

Variable	*t*-statistics	Critical Value	Prob.	Conclusion
CO_2	-1.888	-4.219	0.641	I (1)
ENC	-1.204	-4.219	0.895	I (1)
CPF	-1.317	-4.219	0.482	I (1)
ELF	-1.628	-4.219	0.386	I (1)
GDP	-3.986	-3.616	0.003	I (0)

From the results, it is evident that in the case of CO_2, ENC, CPF, and ELF are integrated at the first difference, whereas, GDP is stationary at the level.

Bounds Test

For checking the long period associations amongst the variables, we have to use the bounds test which will enable us to report the linkages amongst the variables

Table 3: Results of Bounds Test

	F-statistics	Critical Values	Prob.	Result
Economic Growth	11.93	I(0) = 3.74, I(1) = 5.06	0.000	Co-integration does exist

The estimated value of *F*-statistics is 11.93 > 5.06, so, we may reject H0 and authenticate that there exists co-integration amid growth, environmental degradation, energy consumption, capital formation, and effective labor force in Pakistan.

ARDL Estimates

ARDL estimates are depicted in the following Table 4.

Table 4: Long Run ARDL Estimates

Variables	Estimates	Standard Error	*t*-ratio	Prob.
CO_2	-4.188*	2.338	-1.791	0.08
ELF	0.404	0.980	0.413	0.68
ENC	2.837*	1.533	1.850	0.074
CPF	5.838	5.664	1.031	0.312

Estimates of the ARDL model, given in above Table 4 show that environmental degradation, energy consumption, and growth are significantly related over a long period which implies that long period association among these variables is present. Findings also indicate that the long period estimate of CO_2 excretions has a negative association with the growth and may be considered the most important culprit of growth in Pakistan for long period. The estimate of energy consumption (ENC) has become positive which implies that in a long period. It may imply that environmental deprivation impedes growth, whereas, energy consumption accelerates the growth in Pakistan. For obtaining the short-run estimates of ARDL methodology, the ECM is derived.

Table 5: Short period Results of the ARDL Model

Variable	Coefficient	*t*-ratio	Prob.
ΔCO_2	-5.43**	-1.694	0.10
ΔENC	0.39*	7.951	0.00
ΔCPF	0.26*	2.306	0.02
ΔELF	0.24	0.415	0.68
ECM(-1)	-0.29	-6.688	.000
R^2	0.69	D.W Statistics	
Adjusted R^2	0.68	1.48	

The result of the ARDL model for error correction term demonstrates that 29% adjustment will take place from short period disequilibrium towards long period equilibrium every year. *R*-square and adjusted R-square of the ARDL model indicate that 69% of variations in growth are caused by environmental deterioration and energy consumption. Whereas, the estimated value of the Durbin-Watson statistics confirms no autocorrelation in the model. Short-run estimates of the ARDL model are supportive of a strong association between environmental degradation, energy consumption, and growth. When carbon emission increases, it causes deteriorating environmental conditions which produces unhealthy impacts on the factors of production and finally, restricts the productivity level. A reduced level of productivity curtails the process of economic performance and economic growth in the country tends to shrink down.

The coefficient value of the short-run estimate of energy consumption is exerting positive effects on growth. Capital formation exerts a positive impact on growth and the impact of an effective labor force on growth is ignorable.

Short-run and long-run estimates of environmental degradation have shown an inverse impact on economic growth which implies that environmental degradation due to increased carbon dioxide emissions has deteriorated the growth. The results are consistent with many types of research that have advocated the negative influence of carbon dioxide on growth (Baek et al., 2009; Iwata et al., 2010; Jayanthakumaran et al., 2012; Moldan et al., 2011; Omri 2013). On the other hand, Lau et al. (2014) found that carbon dioxide emissions exert positive effects on the economic growth in Malaysia. Soyatas and Sari (2009) and Ang (2007) established positive effects of CO_2 emissions on GDP for Turkey, and Arouri et al. (2012) found the same kind of link for MENA countries.

In the case of the link between growth and energy consumption, short and long period coefficients explain the positive effects of energy consumption on growth. It means that an increase in energy consumption may support to upsurge in the growth in Pakistan. Our result is identical to Wang et al. (2013) for China, Janthakumaran et al. (2012) for India and China, and Ang (2007) for France. Energy becomes an imperative component of the production process, consequently, a higher limit on energy consumption might lead to higher growth (Sharma 2010). Capital formation has an encouraging effect on growth. This finding becomes analogous to findings derived by the researchers (Levine and Renelt, 1992; Lauthier Islam, 1996; Moreaub, 2012).

Diagnostic Tests

Table 6: Diagnostic Tests and Conclusion

Diagnostic Tests	H0	Prob.	Conclusion
Bruesh-Godfrey LM Test	H0: Serial correlation exists.	0.06	Serial correlation does not exist
Ramsey ResetT Test for Mis-specification	H0: Mis-specification of model	0.46	Correctly specified model
J-B Test	H0: Error term is normally distributed.	0.28	Error term is normally distributed
ARCH Test Hetroskedasticity	H0: Homoskedasticity.	0.14	Do not reject H0

The probability value of the Breusch-Godfrey LM test is 0.06 which proves no serial correlation. Results of Ramsey's RESET test authenticate the correct specified model. J-B test is applied to check the normality of residuals to see that residuals are normally distributed. The classical Linear Regression Model assumes residuals to be normally distributed. The probability value of 0.495 expresses the normal distribution of the residuals. The ARCH test is used to find out autocorrelation. The probability value of the ARCH test implies that there is no autocorrelation in the model.

Stability Tests

For analyzing the stability of the model in short and long periods, we have plotted CUSUM and CUSUMS. Since there is no divergence in CUSUM and CUSUMS graphs, so it authenticates that in the ARDL model, the short and long period parameters are found to be stable.

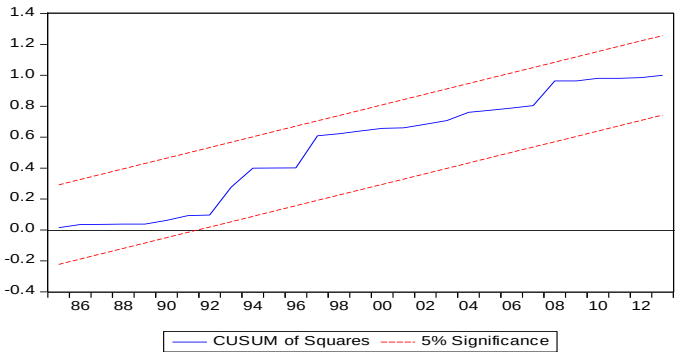

Figure 1: CUSUMS

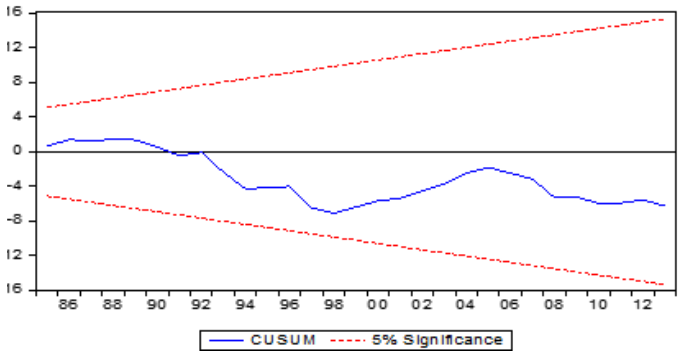

Figure 2: CUSUMS

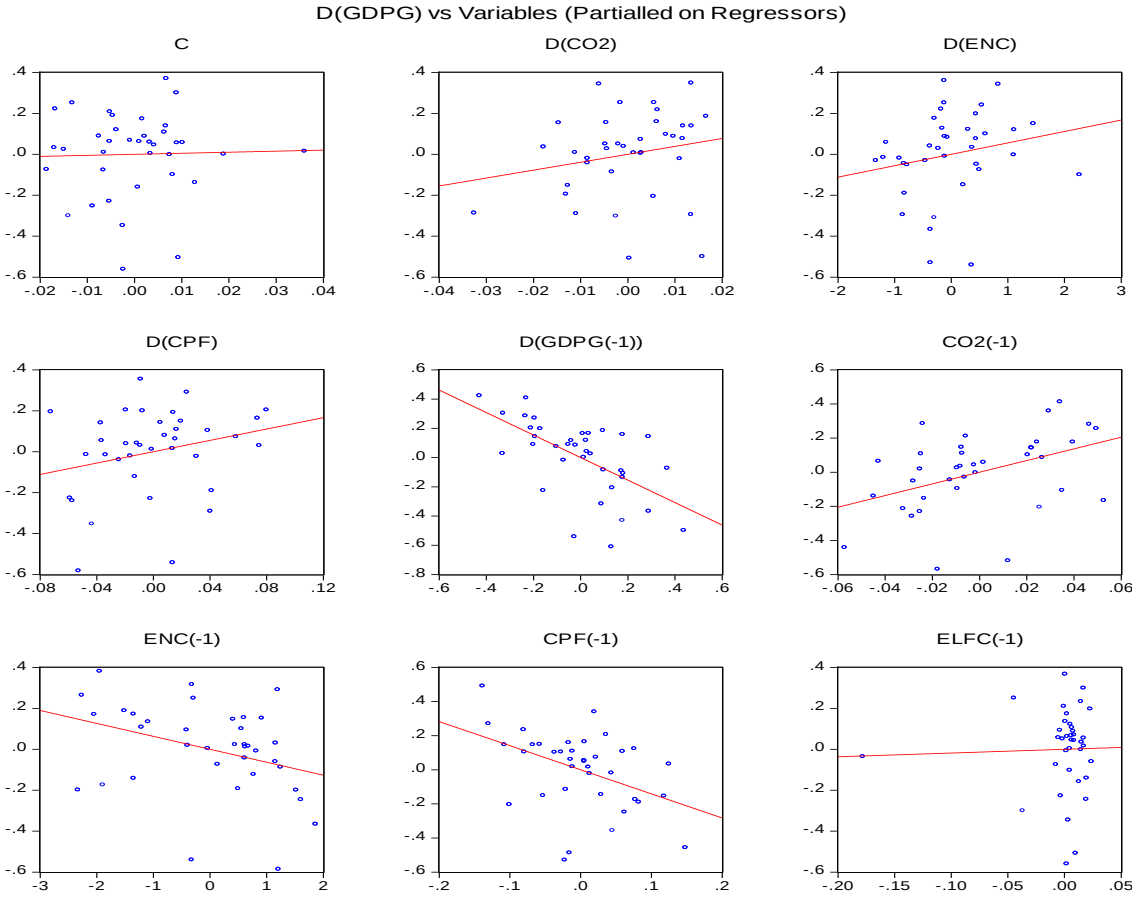

Figure 3: Plots of Leverage Plots

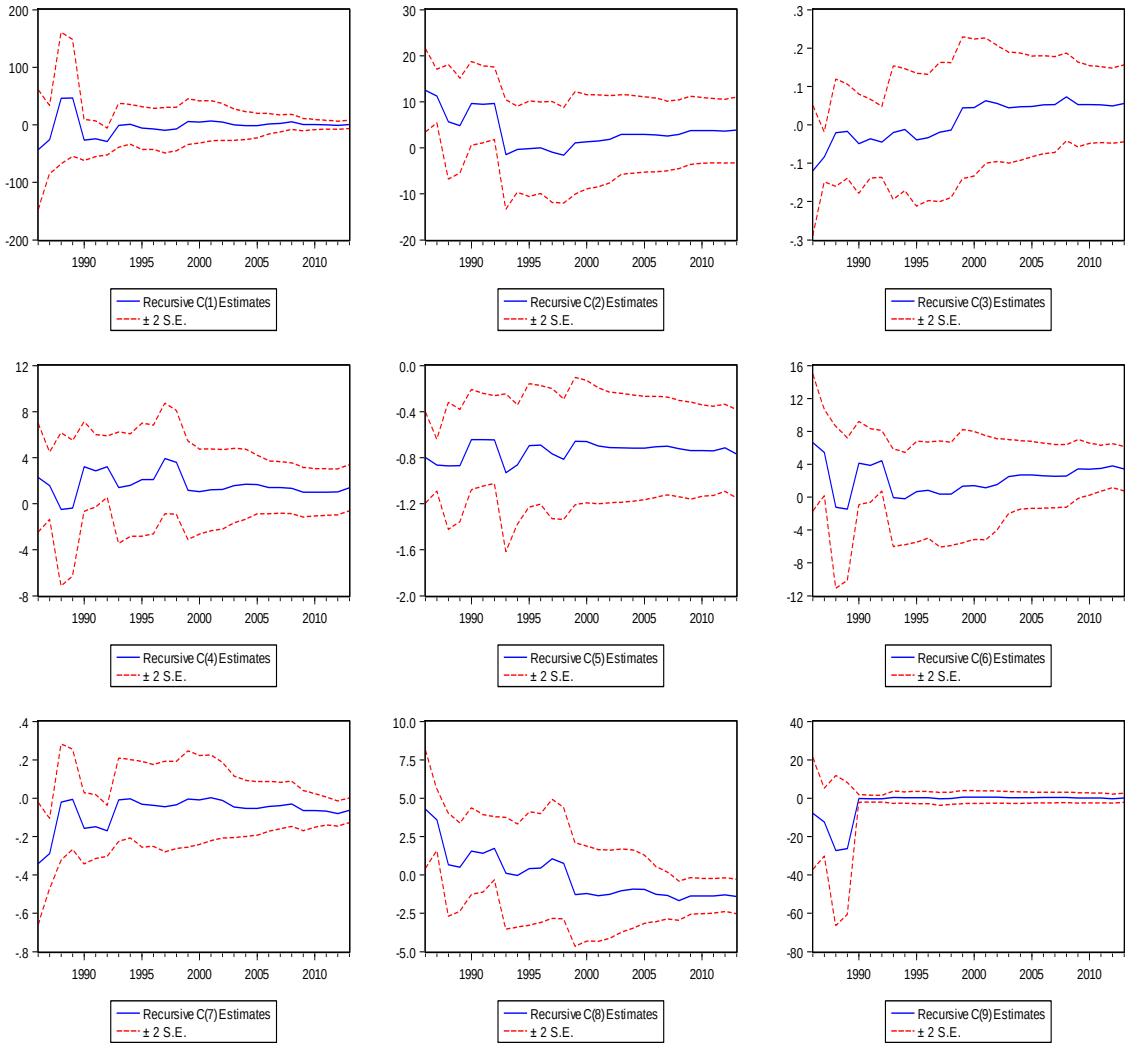

Figure 4: Graphs of Recursive Coefficients

CONCLUSION AND POLICY RECOMMENDATIONS

This research work has attempted to explore that does environmental degradation and energy consumption impede growth in developing economies with a specific focus on Pakistan by using the ARDL bounds testing technique. Findings of the paper have claimed that environmental degradation has been found as a major culprit and impeding factor of growth in Pakistan. Whereas, energy consumption is an imperative determinant for accelerating growth in Pakistan. The findings show the negative impact of CO_2 on economic growth. Our results suggest the positive effect of energy consumption and capital formation on growth in Pakistan. It is concluded that energy consumption and capital formation are major factors of growth in Pakistan. Therefore, lessening the level of CO_2 emissions and increasing the level of energy consumption and capital formation can raise the growth rate of Pakistan. So, it will be sensible to take into account their relationship while designing energy consumption, environmental conservation, and capital formation policies to uphold accelerated economic growth in Pakistan.

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