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AN ARDL ANALYSIS OF TRADE OPENNESS AND TECHNOLOGICAL INNOVATION: A DIVERSE BLESSING FOR ENVIRONMENTAL SUSTAINABILITY IN PAKISTAN

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Article Info

Abstract

The study investigates the impact of trade openness and technological innovation on environmental sustainability in Pakistan from 1990 to 2020. In this study, Augmented Dickey Fuller and Phillips Perron Tests for unit root, ARDL bound test approach for long run and error correction model test for short run analysis were applied. The empirical findings of the study indicate that technological innovation exerts meaningful impact on environmental sustainability in the short run and the long run scenario. Moreover, a 1% increase in technological innovation causes a 0.000001 % increase in CO2 emissi0n in the l0ng run and a 0.0000024 % in the short run. Also, the significant positive effect of trade openness on environmental degradation was observed, where a 1% increase in trade openness led to 0.005 % increase in CO2 emission in the long run. At end, the energy consumption adds more pollution in the environment of Pakistan in long run only and the short run results of population and environmental degradation are positive and significant in Pakistan. The policy implications can be suggested to the government of Pakistan in revising energy policy and focusing on green energy sources to attain environmental sustainability. Furthermore, government must refine its trade policy that reduce the bad effects on carbon emissions in Pakistan, such as focusing on green industrialization through research and development.

Keywords:
Environmental Sustainability, Technological Innovation, Trade Openness, Energy Consumption, Green Industrialization

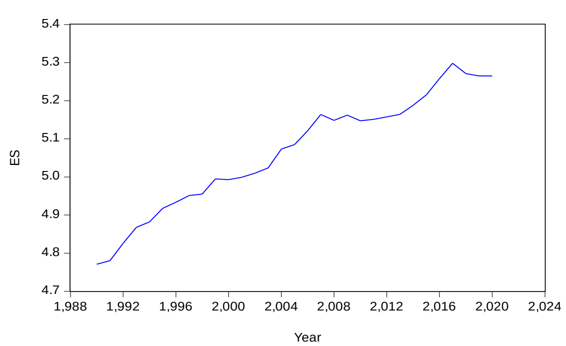
Introduction

From past decades, the debates of climatic change has emerged as one of the most pressing international issues (Han et al., 2025), seeking the attention of policy makers for the environmental sustainability. This climate change affects ecological system and living organisms, especially, human beings, driving many drastic changes in global environment and biodiversity (Nimma et al., 2025). The global environment has deteriorated due to the excessive emission of dangerous gases, particularly, CO2. The report of IEA (2024) indicates that CO2 emissions generating from energy sector rose by 1.1% globally in 2023, reaching a new record of 37.4 billion tons. Furthermore, the urgency of climate change highlights in the Paris Agreement, requiring a 25% decrease in GHG emissions by restricting the global temperature rise to below 2 °C to 1.5 °C (Almulhim et al., 2025).

The renewable energy sources like wind, solar, geothermal, and biomass are considered as the crucial enablers to mitigate greenhouse gas emissions (Khalid et al., 2024) and these energy resources are more critical for technological advancement (Adebayo et al., 2023). In the context of European countries and the United States, technological innovation positively influences environmental sustainability, whereas in China, it has a negative impact on environmental sustainability (Fernandez et al., 2018). Also, this innovation plays more significant role to minimize environmental degradation in fast-growing regions than in slow-growing ones (Amri & Nasri et al., 2025).

Foreign trade is an essential factor of economic development which contributes important role in economic growth, energy use, and CO2 emissions (Chen et al. 2021). It deteriorates environmental quality and creates positive impact on carbon emission (Chen et al., 2021 & Ansari et al., 2020). Moreover, the condition of environmental sustainability in D8 countries are vulnerable due to unsustainable trade processes in the production of goods and services (Musah et al., 2021). H0wever, trade 0penness benefits envir0nmental sustainability, as its negative c0rrelati0n with carb0n emissi0ns suggests that increased trade 0penness d0es n0t necessarily lead t0 higher carb0n emissi0ns (Amin et al., 2020).

The demand of energy in spite of electricity shortage in Pakistan is surging persistently in the presence of high population growth rate. With this higher population, CO2 emission may be 2.9 tons per capita in Pakistan by the end of 2025 (Nguyen et al., 2024). As climate change intensifies, Pakistan stands as the 8th m0st vulnerable c0untry in S0uth Asia. (Wang et al., 2025). The figure-01 displays a rising trend of environmental degradation over time in Pakistan. This trend indicates deteriorating environmental situations, potentially driven by rapid industrialization, expansion in urbanization, higher energy use and uncontrollable population. This environmental situation exerts adverse effects on bio-diversity, water and air quality, and public health. On the basis of these effects, the ecological and socio-economic consequences like the downfall in agricultural production, shortfall in water supply, and increased vulnerability to natural disasters may arise in Pakistan. Therefore, an urgency is required for policy interventions and sustainable development strategies to control this upward trend to maintain a balance between economic growth and environmental conservation.



In Somalia, Hassan & Hussein (2024) examined the relationship among energy consumption, urbanization, and CO2 emissions. On their recommendation, we conduct this study in Pakistan, incorporating technological innovation and trade openness as crucial factors of environmental sustainability. The aim of this study is to analyze the effect of techn0l0gical inn0vation and trade openness on envir0nmental sustainability in Pakistan, particularly its r0le in reducing CO_2 emissi0ns. By analyzing these components, we try to propose policy recommendations for supporting sustainable economic growth while reducing environmental degradation. The findings of this study will contribute to formulating evidence-based policies that enhance sustainability efforts and climate resilience in the region.

This study is organized as: Chapter 2 summaries the literature review that provides the in-depth knowledge of key indicators of environmental sustainability. The third chapter displays data collection along with methodology and chapter 4 presents the results and discussion of the study. At the end, the last chapter concludes the study with proper policy implications.

2. Literature Review

In this section, we present earlier researches on the relationship between trade, energy use, technological innovation, population and environmental degradation.

Energy sector plays pivotal role in production process to accelerate economic growth (Salari et al., 2021). As environment concerns, Waheed et al. (2018) found that renewable energy consumption exerts negative impact on environment in Pakistan. In this situation, more the use of renewable energy emitted less carbon dioxide in the environment. Similarly, Ritu and Kaur (2024) conducted a research on environmental sustainability in India from 1997 to 2020. They employed ARDL bound testing approach to analyze the key determinants of environmental sustainability for short and long time period. The inverse relationship of Trade and energy consumption with environment came to be known under this investigation. It means that more trade and energy consumption lead to less environmental degradation and brings a sustainable environment situation in India.

On the other hand, the study of Sulaiman and Abdul-Rahim (2017) highlighted the link among energy use, economic growth and CO2 emissions in Malaysia in1975-2015. They proved that energy use, economic growth and CO2 emissions are positively associated to each other. The higher use of energy and economic activities lead to more population emissions. In light of existing literature, the current study is initiated on given hypothesis.

H_1: Renewable energy use negatively affects CO_2 emissi0ns, supp0rting a cleaner and m0re sustainable envir0nment.

In the context of Pakistan, Khan & Safdar (2023) conducted a study on foreign trade and the environmental degradation during 1980–2020. They employed ARDL and NARDL approach for the analysis of the study and they concluded that pollution increases due to an increase in trade. A panel data study was conduct in 66 developing states by Van Tran (2020) to analyze the effect of foreign trade on environment from 1971 to 2017. They utilized the GMM approach to identify environmental quality and they pointed out that foreign trade adds more pollution in the environment. The study of Nathaniel (2020) about the relationship between urbanization, Economic growth, trade openness, and environmental degradation on 1971–2014 in Indonesia is also verified the previous studies positive impact of energy consumption and trade openness on environmental degradation. Additionally, the researches of Le et al. (2016) and Liu et al. (2022) show that trade openness has a positive effect on environmental badly. From earlier studies, this study is started with the following hypothesis.

H_2: Trade 0penness has a significant influence 0n environmental quality, either by pr0m0ting sustainable practices 0r increasing p0llution thr0ugh industrial expansi0n.

For the achievement of SDG-7, technological innovation is one of the most pertinent instrument of Egypt to mitigate CO2 emissions and enhance economic sustainability (Ibrahiem, 2020). Ali et al. (2016) explored the importance of technological innovation in the context of environment degradation in Malaysia. But they failed to discover a significant impact of technology on environmental pollution. In the light of climatic change, Abdi (2023) focused on environmental sustainability in 41 SSA countries from the time period of 1999-2018. The aim of this study was to examine the effects of economic complexity and energy use on CO2 emissions by using PMG cointegration analysis. The findings of this analysis indicated that renewable energy use lessens environmental degradation in the short run and long run. On the contrary, economic complexity enhances environmental quality only in the long run. Moreover, economic growth affects badly to the environment in the long run as well as in short-run.

Conversely, Villanthenkodath & Mahalik (2022) investigated technological innovation and environmental quality in India and the impact of technological innovation on environmental quality is positive. However, Anwar & Malik (2021) research demonstrates the same results of G-7 countries, representing that technological innovation hurts the environment severely. We develop the following hypothesis on the basis of previous researches:

H_3: Techn0l0gical inn0vation has a significant negative impact 0n CO_2 emissi0ns, c0ntributing t0 envir0nmental sustainability in Pakistan.

In case of population concerns, Yang et al. (2021) investigated the long run effect of population aging on CO2 emissions in OECD countries for 1971-2016. The panel data study's results recommend that population has an inhibitory influence on CO2 emissions, indorsing the situation for the elderly's energy-saving low-carbon use. Unlikely, the study of Zhang and Tan (2016) concluded positive impact of population aging on carbon emissions in 29 Chinese regions. In the western region, the impact of population aging is positively linked with air pollution but its effect is negative in the eastern region. In the central region, there is no significant connection between aging and carbon emissions. To take more insight about the connection between population aging and environmental degradation, Yang and Wang (2020) conducted a study to explore the non-linear association between population aging and environmental degradation in 10 Chinese provinces. They analyzed that population aging has a negative effect on carbon emissions, observing the greater impact in case of the elderly share exceeds 13 %. In 07 South Asian countries, Khan et al. (2021) estimated the significant impact of the working-age population on carbon emissions and EFP. Moreover, Dimnwobi et al. (2021) investigated the population-environment nexus for 05 populous African economies from 1990 to 2019. The outcomes of the study indicated that population growth, density of population, and age structure significantly raise environmental degradation. From earlier studies, this study is commenced on the following hypothesis.

H_4: P0pulation has a significant p0sitive impact 0n CO_2 emissi0ns, c0ntributing t0 less envir0nmental sustainability in Pakistan.

In the light of above-mentioned literature, we come to a point that the variables like trade, renewable energy consumption, technological innovation and population aging are more pertinent indicators of environmental sustainability in different global regions with various timelines. In this regard, Hassan & Hussein (2024) gave clear direction for future investigation on environmental degradation. They suggested further researchers to include technological innovation as an influential indicator for framing effective policy to maintain environment sustainability. As per the given direction, we investigate the impact of technological innovation and trade on environmental sustainability in Pakistan for the period of 1990 to 2020.

3. Data Collection and Methodology

3.1 Data Source

The objective of this study is to investigate the impacts of trade and technical innovation on environmental sustainability in Pakistan. For this, the secondary time series data were used for the time period of 1990 to 2020. Data have been taken from World Bank Indicators database of all the variable used in this study.

3.2 Methodology

3.2.1 Suggested Variables

In this study, we use five variables such as environmental sustainability, technical Innovation, trade openness, population and energy consumption. The description of the variables are given in table 01.
TABLE 1: VARIABLES DESCRIPTION

Variable	Proxy	Symbol	Measurement Unit	Variable Type
Environmental Sustainability	Carbon Dioxide Emissions	ES	Kilotons (kt)	Dependent Variable
Trade openness	Trade	TO	% of GDP	Independent Variable
Technological Innovation	Patents Applications of Residents & Non-residents	TECH	Number of Applicants	Independent Variable
Population	Population ages 15-64	POP	% of total population	Controlled Variable
Energy Consumption	Renewable Energy Consumption	EC	% of total final energy consumption	Controlled Variable

3.3.2 Econometric Model

The econometric model of this research investigation in functional form is highlighted below:

$$ES = f\,(Tech, TO, POP, EC) \text{ ------------------------- } (1)$$

The above functional form can be converted into econometric equation as:

$$\ln ESt = \beta 0 + \beta 1\ Techt + \beta 2\ TOt + \beta 3\ POPt + \beta 4\ ECt + et \text{ ------------------}(2)$$

In equation 2, the environmental sustainability was taken into log form for the fulfillment of basic assumption of OLS method (Khan, A. et al., 2024), β0 used as intercept, β1, β2, β3 and β4 added as slope co-efficient and et was residual term.

3.3.3 Econometric Technique

For time series study, unit root is checked initially to take robust results. The most suitable and powerful method to tests stationary in the variables were Augmented Dickey Fuller and Phillips-Perron tests (Khan et al., 2022). Moreover, these tests are appropriate for handling negative values and sample data-set. In the light of Unit root investigation, we check the variables' stationary at level or at first difference. In case of mixed orders, some variables are stationary at level and other are at 1st difference, the Autoregressive distributed lag approach (ARDL) is the most favourable technique for long run as well short run analysis (Hassan & Hussein, 2024). The current study econometric model can be expressed in ADRL framework as:

$$\Delta\ Ln\ ES_t = \beta_0 + \lambda\, ln\, ES_{t-i} + \alpha_1\, Tech_{t-i} + \alpha_2\, TO_{t-i} + \alpha_3\, POP_{t-i} + \alpha_4\, EC_{t-i} + \sum_{i=1}^{p} \beta_i \Delta\, ln\, ES_{t-i} + \sum_{j=0}^{q1} \beta_{2j} \Delta\, Tech_{t-j} + \sum_{j=0}^{q2} \beta_{3j} \Delta TO_{t-j} + \sum_{j=0}^{q3} \beta_{4j} \Delta POP_{t-j} + \sum_{j=0}^{q4} \beta_{5j} \Delta EC_{t-j} + e_t \text{ ---------- } (3)$$

In this context, β0 is the constant, p indicates the optimal lag length of the regress and q1, q2, q3 and q4 show the optimal lags length of the regressors. In equation 3, Δ sign represents the 1st difference operator for handling non-stationary data and et signifies the error term. The equation 3 captures the short run and long run dynamics.

The study of Jama & Abdi (2024) suggests that the ARDL cointegration technique initiates with bound testing approach to examine the existence of cointegration. In the presence of cointegration, we move forward short run analysis through error correction technique and observe the error correction term co-efficient to investigate the speed of the adjustment toward long-run equilibrium.

4. Result and Discussion

In this section, our focus is to analyze and evaluate the study's findings. This part is divided into different subsections such as descriptive analysis and pre-regression tests. Moreover, unit root problem is examined through Augmented Dickey-Fuller test owing to time series data, and, at the end, analyzed the long run and short relationship between study variables by using the ARDL approach.

4.1 Descriptive Statistics

In descriptive analysis, we observe the measures of location and variability in data-set. Table 2 presents the descriptive statistics of lnES, POP, EC, TECH and TO. The mean values of lnES, POP, EC, TECH and TO variables are 5.065869, 53.73946, 49.16452, 877.0833 and 32.36923 respectively. Additionally, the standard deviation values of lnES, POP, EC, TECH and TO variables are 0.152174, 1.556388, 4.216440, 308.1467 and 4.456995 respectively. The kurtosis values of POP, TECH, EC and TO lie towards 3 which is the indication of variables normality.

Table: 2 Descriptive Statistics

	lnES	POP	EC	TECH	TO
Mean	5.065869	53.73946	49.16452	877.0833	32.36923
Median	5.084965	53.24060	48.00000	795.5092	33.28423
Maximum	5.298283	57.13958	58.10000	1635.422	38.49932

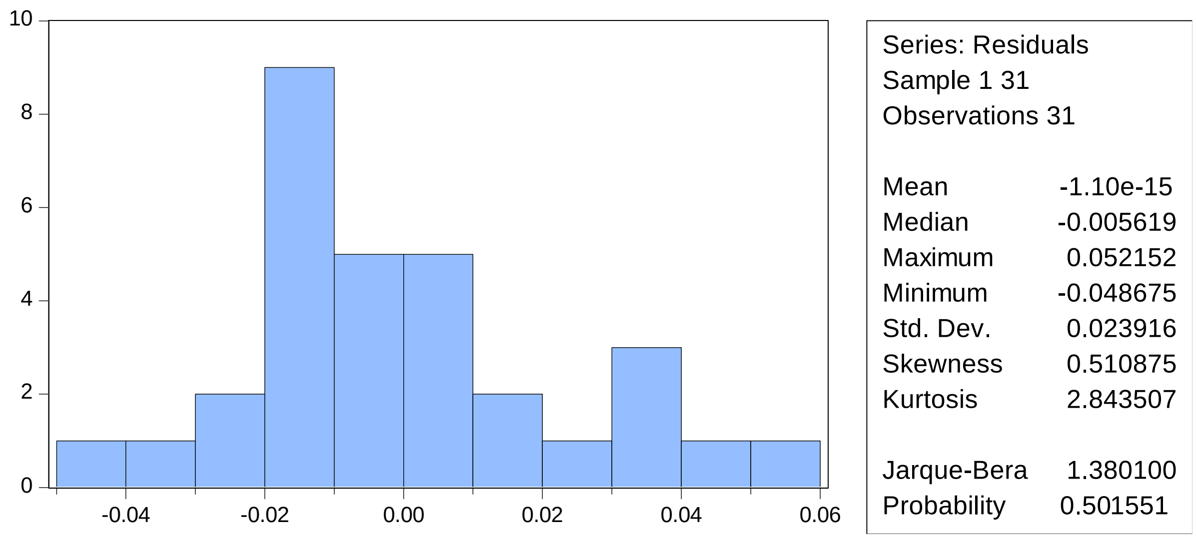
Minimum	4.771043	52.05206	42.10000	488.9800	21.45997
Std. Dev.	0.152174	1.556388	4.216440	308.1467	4.456995
Skewness	-0.304043	0.956546	0.363574	0.569795	-1.078272
Kurtosis	2.044253	2.678589	2.408036	2.486592	3.378030
Observations	31	31	31	31	31

4.2 Diagnostics Test

To ensure the robust findings, these tests are performed before the estimation of a regression model. After performing these test, we are able to understand the nature of the data and model specification in the light of the assumptions for regression analysis.

4.2.1 Normality Test

According to this assumption, we check that the residuals are normally distributed or not. For this, we utilize Jarque- Bera test by using its co-efficient value along with its p-value. If the p-value is greater than 5%, the residuals are normally distributed as a rule of thumb. Therefore, our study residual are also normally distributed as per given rule.



4.2.2 Multicollinearity

Multicollinearity test is used to identify correlation between independent variables. So, we find variance inflation factor (VIF) for this. When the value of VIF is less than 10, it means that there is no multicollinearity among regressors. From table 3, we can see that there is no multicollinearity between independent variable. In the last column of table 3, the VIF values of all independent variable are less than 10 that is the indication of no multicollinearity among regressors.

Table 3: Correlation & VIF

Variable	EC	TECH	TO	POP	VIF
REC	1.000000				3.7574
TECH	-0.113837	1.000000			4.8877
TO	0.249386	0.216734	1.000000		1.1448
POP	-0.540246	-0.679783	-0.295995	1.000000	6.6302

4.2.3 Heteroskedasticity Test

In this test, we analyze the variance of error terms which are constant across all levels of the independent variables. In this regard, we use Breusch-Pagan-Godfrey test to examine heteroskedasticity. According to this test, we focus on the p value of Obs* R2 statistic, if the p-value of Obs* R2 statistic is greater than 5% level of significance, the distribution is homoscedasticity and table 4 explains this picture of homoscedasticity.

Table 4: Heteroskedasticity Test (Breusch-Pagan-Godfrey)

F-statistic	1.855212	Prob. F(4,26)	0.1486
Obs*R-squared	6.883317	Prob. Chi-Square(4)	0.1422
Scaled explained SS	4.463093	Prob. Chi-Square(4)	0.3469

4.2.4Autocorrelation Test

We use the autocorrelation test in regression analysis, especially in time series data, to detect whether the residuals (error terms) are correlated with their own past values. Breusch-Godfrey Serial Correlation LM Test is applied to analyze autocorrelation. For this, the p-value of Obs* R2 statistic is observed its existence if p-value is less than 5% level of significance. But table 5 shows that the p-value is greater than 5% level of significance i.e., 0.3670, this is direction of no autocorrelation.

Table 5: Autocorrelation (Breusch-Godfrey Serial Correlation LM Test)

F-statistic	0.829680	Prob. F(2,24)	0.4483
Obs*R-squared	2.004733	Prob. Chi-Square(2)	0.3670

At end, the diagnostic tests verifies the basic assumptions of OLS method. Furthermore, issues like non-normality, multicollinearity, heteroskedasticity and serial correlation are not detected. After this careful investigation, we move forward to check the stationary in the variables due to time series data involvement.

4.3 Unit Root Test

Here, we use two unit root tests i.e., ADF and PP to investigate the stationary in all variables and results of these tests are highlighted in table 6. We can see that only POP variable is stationary at level in both tests but all other variables are stationary at 1st difference. Therefore, ARDL approach to cointegration is feasible in the presence of mixed order of integrated variables (Khalifa, 2024).

Table 6: Unit Root Test

ADF

Variables	Level		1st Difference		Level of Integration
	T-Statistics	P-Value	T-Statistics	P-Value	
ES	-1.9818	0.5873	-4.9772	0.0021*	**I(1)**
POP	-4.2202	0.0123*	-	-	**I(0)**
TO	-1.8610	0.6493	-5.6500	0.0004*	**I(1)**
EC	-2.8733	0.1842	-5. 4216	0.0006*	**I(1)**
TECH	-1.4862	0.8120	-5.1015	0.0015*	**I(1)**

Phillips-Perron Test

Variables	Level		1st Difference		Level of Integration
	T-Statistics	P-Value	T-Statistics	P-Value	
ES	-2.0938	0.5282	-4.9772	0.0021*	**I(1)**
POP	-4.2425	0.0154*	-	-	**I(0)**
TO	-2.0987	0.5257	-5.6336	0.0004*	**I(1)**
EC	-2.6581	0.2594	-6. 4034	0.0001*	**I(1)**
TECH	-1.4009	0.8400	-5.6948	0.0004*	**I(1)**

4.4 Bound Test

In ARDL approach, we check the existence of long run cointegration among variables. So, we applied the Wald test, the result of this test has been given in table 7. From F-Bound test, we acquired F-statistic value of 36.58444 and we compared it with the upper bound I(1) value. The value of F-statistic is greater than I(1) value at 1%, 5% and 10% level of significance, we conclude that the long run cointegration exists among all variables.

Table 7: Bound Test

Test Statistic	Value	Significance	I(0)	I(1)
F-statistic	36.58444	10%	2.20	3.09
K	4	5%	2.56	3.49
		1%	3.29	4.37

4.4 ARDL-Long Run Analysis

In the existence of long run cointegration, we analyze the long run relationship between dependent and independent variable individually kept other explanatory variable as constant. From table 8, the impact of trade openness on environmental degradation is positive and significant. If 1% increase in trade openness leads to 0.005 % increase in CO2 emission which means that trade openness is a source of environmental degradation. But its intensity is not severe to bring environmental sustainability in Pakistan. The empirical studies of Jama & Abdi (2024), Yang & Usman (2021) and Ponce & Alvarado (2019) confirm this positive and significant relationship of trade and environmental sustainability.

As per table 8, the more energy consumption leads to more CO2 emission and 1% raise in energy consumption brings 0.024% more environmental pollution. So, the energy usage adds more pollution in the environment of Pakistan. The current study's findings show that energy consumption affects badly the environmental sustainability.

The impact of technological innovation on CO2 emission is more crucial for Pakistan economy according to this study's results. When the 1% increase in technical innovation causes 0.000001 % increase in CO2 emission. In this scenario, the technological innovation brings environment sustainability in Pakistan. Consequently, this factor plays pivotal role to decrease environmental degradation. The study of Khan et al. (2024) confirms these results.

Table 8: ARDL- Long Run (2, 1, 0, 0, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
POP	-0.0084690	0.0083210	-1.017769	0.3216
TO	0.0054700	0.0012110	4.517488	0.0002
EC	0.0241060	0.0023130	10.42374	0.0000
TECH	-0.0000001	0.0000004	-1.990179	0.0412
C	6.6058930	0.5382340	12.27327	0.0000

4.5 ARDL-Short Run Analysis

The results of short run analysis is presented in table 9, indicated the population applies the positive and significant impact on CO2 emissions. In short run, 1% increase in population brings 0.11% increase in environmental degradation. So, the population is a factor which can be created a hurdle in the way of environmental sustainability in Pakistan. The study of Mohsin et al. (2021), and Nama Horo et al. (2021) confirm the positive association between population and environmental degradation.

The effect of technological innovation on CO2 emissions is negative and significant. This implies that 1% rise in TECH reduces carbon emissions by 0.0000024% in the short term. Consequently, the technological innovation is a most beneficial driver of environmental sustainability in Pakistan.

Furthermore, the error correction term is used to analyze the short run impacts of the regressors on CO2 emissions. The ECT coefficient is negative and statistically significant, indicating convergence dynamics and the model adjusts approximately 44% of short-run to converge into long run equilibrium.

Table 9: ARDL Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(lnES(-1))	-0.370487	0.067472	-5.490961	0.0000
D(POP)	0.108605	0.007225	15.03264	0.0000
D(TECH)	-3.93E-05	8.05E-06	-4.879015	0.0001
D(TECH(-1))	-2.40E-05	8.23E-06	-2.919683	0.0088
ECT	-0.437797	0.026292	-16.65147	0.0000

4.6 Stability Test

The two stability tests like Cumulative Sum, and the Cumulative Sum Square are applied and results are displayed graphically. It determines systematic variations in regression coefficients, while the CUSUMSQ test argues parameter deviation from reliability. The coefficients in the ECT value is unaffected when the plot of residuals stays inside the critical bound of the 5% significance level. Figures 2 and 3; show two plots that, at the 5% level of significance, are inside the critical bound, indicating that the model is structurally unchanged.

Figure 2

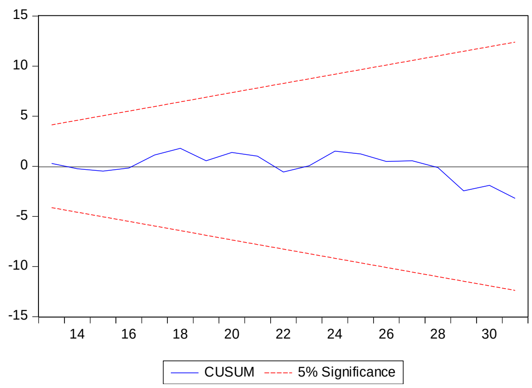
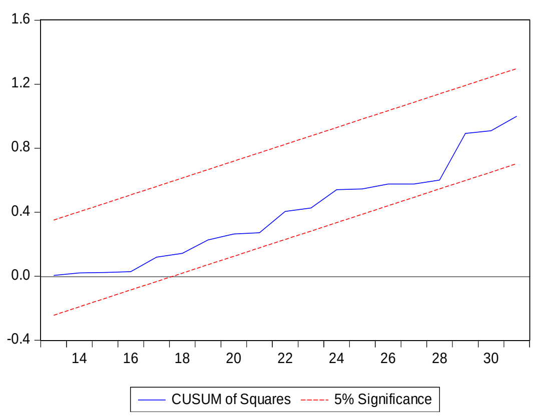


Figure 3



5. Conclusion & Policy Implications

The study investigated the impact of trade openness and technological innovation on environmental sustainability in Pakistan from 1990 to 2020 utilizing ARDL bound test approach. The empirical findings of the study indicate that technological innovation exerts meaningful impact on environmental sustainability in short run and long run scenario. Moreover, the 1% increase in technological innovation causes 0.000001 % increase in CO2 emission in Pakistan in long run. Similarly, the 1% increase in technological innovation causes 0.0000024 % increase in CO2 emission in Pakistan in short period of time. Resultantly, technological innovation is a main driving component of environmental sustainability in Pakistan. Trade openness is another meaningful component of environment sustainability in Pakistan in long run only. The impact of trade openness on environmental degradation is positive and significant and 1% increase in trade openness leads to 0.005 % increase in CO2 emission which means that trade openness is a source of environmental degradation.

In this study, energy consumption is 3rd component environmental degradation in Pakistan. The more energy consumption leads to more CO2 emission and 1% raise in energy consumption brings 0.024% more environmental pollution. So, the energy usage adds more pollution in the environment of Pakistan in long run only. The short run results of population and environmental degradation are positive and significant in Pakistan. In the context of findings, 1% increase in population brings 0.11% increase in environmental degradation. So, the population is a factor which can be created a hurdle in the way of environmental sustainability in Pakistan.

On the basis of current results, the policy implication can be suggested to the government of Pakistan concerning energy consumption. Pakistan's government must revise its energy policy and focus on green energy sources for the attainment of environmental sustainability. Furthermore, it must subsidize renewable energy resources, improve in energy efficiency, and impose tax on fossil fuel use.

Second, government must refine its trade policy that reduce the bad effects on carbon emissions in Pakistan, such as focusing on green industrialization through research and development. In addition, policymakers may give suggestion to control population through public awareness and deliver all information to them about environmental degradation.

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