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Investigating the Nexus between Energy Consumption and Environmental Degradation: Empirical Evidence from Pakistan

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Abstract

The primary goals of this study are to evaluate the impact of energy consumption (EC) on environmental deterioration and to test the environmental Kuznets Curve (EKC) in the context of EC in Pakistan. This research examines data from 1990 to 2020 and uses ARDL methods for estimate. This study discovered that non-renewable energy (NREN) and GDP growth had an optimistic and noteworthy influence on CO2. However, renewable energy (REN) has a negative and substantial impact on CO2. The results also confirmed the EKC in Pakistan, which found an inverted U-shaped bond between GDPg and CO2. Furthermore, EKC has a turning point of 1.55%. Furthermore, this analysis contradicts the hypothesis H01 and concludes that energy use has a considerable impact on CO2. Similarly, dismisses H02 and concludes that it has a varying magnitude influence on carbon emissions. Similarly, rejects the H03 and concludes that the EKC occurs in Pakistan as a result of EC. As a result, this study indicated that EC has a significant impression on CO2 levels, as well as confirming the EKC in Pakistan. It is advised that the government prohibit the use of NREN and support the use of REN for household and commercial purposes in order to reduce CO2 in Pakistan and other developing nations. Furthermore, the government must boost economic growth after reaching a tipping point in order to minimize CO2 in Pakistan and other developing nations.

Keywords: non-renewable energy; renewable energy; EKC; GDP; CO2;

Background of the Study

Economic growth (GDPg) is vital for all countries. It is also critical to achieve sustained economic growth. As a result, governments may strive to achieve economic development by lever-

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aging economic growth to gain wealth. Economic growth needs more energy. This is because economic actors use energy in all parts of their activities, including production, consumption, and transportation. When high GDPg is desired, more energy is required. However, as countries' economies grow, environmental degradation (CO_2) has become a concern. As a result, scholars and policymakers have devoted much of their attention and discussion to environmental degradation. Energy sources can be categorized as REN or NREN. CO_2 are mostly created by the use of fossil fuels (later FF) to generate power, despite the fact that governments have the choice of employing renewable sources. The usage of FF has had a substantial impression on CO_2. In contrast, the utilization of REN has grown. According to available studies, REN contribute to minimize CO_2 emissions since they are undoubtedly manufactured and their usage does not increase CO_2 emissions. Furthermore, numerous countries prefer to obtain energy from nuclear sources. As a result, certain countries have expanded their usage of nuclear energy. To summaries, fossil fuels have accounted for a significant portion of global energy output, while renewable sources have steadily increased. This type of energy production system generates considerable CO2 emissions, contributes to climate change and global warming, and has socioeconomic effects. As a result, an examination of CO2 emissions on a national scale, spanning a group of countries, particularly those that release a large amount of CO2, is critical when evaluating the negative effects on human health (Kartal, 2022).

As a result, ClCh, and GWarm, as the most serious threats to human society, are closely related to energy consumption (later on ENU) and greenhouse gas emissions (later on GHG). The residential sector, which accounts for 27.00% and 17.00% of global ENU and CO2, respectively, plays an imperative role in reducing global ClCh (Nejat *et al.*, 2015). In addition, climate change (later on ClCh) and global warming (later on GWarm) are two of the most important environmental concerns, posing a growing threat to human existence and progress. GHGs, notably CO_2, are the primary cause of ClCh. CO2 is primarily produced by the combustion of FF for energy generation and transportation, accounting for roughly 85.00% of global CO_2. To minimize CO_2, it is necessary to search for alternative energy sources (Li & Yang, 2016). The GWarm concern for CO2 appears in a rising public directive, and the development plan is heavily dependent on whether sustained GDPg creates CO_2 or whether such GDPg is adequate to compensate for the cost of CO2. However, finite natural resources (later NRC) are employed as inputs in the industrial process. If the functional relationship between NRC and current development methods is not broken, the environment will suffer (Grossman & Krueger, 1995). Energy has long been one of the most important issues facing economic concerns (Zhong *et al.*, 2020). As such, energy creation and sources are vitally important. Wind, solar, and hydroelectric power have recently emerged as the most popular energy sources (Depren *et al.*, 2022).

Energy is crucial to long-run (later LR) economic performance, but welfare is compromised by variables such as rising energy consumption due to population expansion, which results in fast ENU sources. However, GHG emissions from FF combustion are to blame for GWarm. As a result, further reliance on this FF to fulfill rising energy demand will exacerbate CO_2 emissions (Gottschamer & Zhang, 2016; Stergaard *et al.*, 2020). Over the last 25 years, academics, ecologists, lawmakers, and economists have focused on environmental quality and pollution issues. The demand for NRC has increased CO_2 emissions. The destruction of the ecosystem is undermining the world's LR social and economic development objectives as a result of unrestricted use of NRC. Pollution and resource overexploitation jeopardize economic systems (Wang *et al.*, 2022).

GDPg and CO2 are tightly related. No country can achieve LR development without employing NREN sources, especially considering current environmental concerns such as GWarm, pollution, and toxic leftover removal, as well as the impact on CO2 generated by GDPg (Cao *et al.*, 2022). Furthermore, resource use is reduced, and environmental degradation is obviously linked. GDPg is further impeded by various forms of energy, which have an influence on CO_2. To maximize LR GDPg, an economy's ability to minimize import prices and increase the renewable energy, as well as improved energy efficiency (Destek & Sinha, 2020; Temiz Dinç & Akdoğan, 2019). A clear and positive link between GDPg and ENU is universally acknowledged. Although concepts have been proposed, there is still a lack of knowledge as to how REN contributes to GDPg. Furthermore, the numerous ramifications of REN generation in both industrialized and developing countries have usual less consideration. Economic development and REN adoption are inextricably linked, however most study focuses on either industrialized or developing nations (Behera & Mishra, 2020). Carbon emissions in the global economy continue to rise, making it more difficult to carry out the Paris Climate Agreement. Indulging in the basic activities that contribute to CO_2 is critical for developing strategies to counteract GWarm. CO_2 is a chronic and severe subject that is receiving government consideration across the world due to its impression on GWarm and the potential interruption of the universal CO_2 cycle. ClCh is the most pressing issue affecting humanity now. ClCh caused by GHGs, particularly CO_2, poses significant threats to human progress (He *et al.*, 2021).

The primary human input to CO_2 emissions is the use of FF. However, certain industrial operations and land-use changes continue to emit CO_2. ClCh and GWarm may have a wide range of serious repercussions, including increased and reduced GDPg. Several researches have been undertaken to highlight the issues surrounding REN, urbanization, CO_2, and GDPg (Rehman *et al.*, 2023). Dong *et al.* (2020) found that REN had a harmful impact on CO_2. Kwakwa (2021) analysis of energy consumption in Ghana indicated that FF continues to account for a large portion of the country's total intake. Still, Akintande *et al.* (2020) observed that when energy demand and ENU grow, so does REN. Likewise, Kwakwa and Alhassan (2018) discovered that urbanization (after URB) and waste utilization had a valuable influence on CO_2 in Ghana, but URB and FF consumption had a negative effect. In contrast, Sadiq *et al.* (2022) study on CO_2, nuclear energy (later NEC), and human progress finds that NEC promotes human progression while foreign debt impedes it. NEC and international debt help to sustain stability. As a result, there is disagreement among scholars on the impression and extent of ENU on CO_2. Furthermore, there is controversy regarding the existence of the EKC theory.

When looking at the evolution of CO_2, it is evident that many countries are responsible for the majority of them. As a consequence, the CO_2 trend in Pakistan, a carbon-producing country, is shown from 1990 to 2020, utilizing the most extensive and easily accessible data. When examining the progress of CO_2 in Pakistan, one can ask (i) whether all factors have a noteworthy impact on CO_2; (ii) whether FF or REN sources are important for CO_2 emissions; and (iii) whether the impression of factors on CO_2 follows a linear trend or if different possessions occur when certain explanatory variable thresholds are crossed. According to the literature, CO_2 emissions are expected to be positive (increased) for fossil fuels and negative (decreased) for renewable sources in general and address these problems by concentrating on the top CO_2 emitters. In line with this, the study focuses on Pakistan, applies the ARDL technique, and uses yearly data from 1990-2020 as the most easily available data. Based on the findings, several legislative measures for CO_2 reduction are proposed, which would assist to lessen environmental harm. As a result, the purpose of this study was to look into the impact of EC on environmental deterioration in Pakistan and to assess the existence of the EKC.

Environmental degradation is a serious issue across the world, causing a variety of concerns (Zhang *et al.*, 2024). As a result, this work provides the following contributions. First, the study addresses key issues in Pakistan (such as measuring environmental damage using CO2 emissions). Second, the study makes use of a diverse set of explanatory factors, including ENU as well as the usage of FF, NE, and REN, all of which have a substantial impression on CO_2. Third, the study takes use of a broad dataset that spans 1990 to 2020 and incorporates all available data. Fourth, as an uncommon technique, the study adopts the ARDL method. However, this study took into account the Pakistani economy with its own set of factors while also evaluating the EKC hypothesis, which is crucial in this situation.

Theoretical Literature

According to Liberty *et al.* (2013), natural resources are required for life to exist. Humans develop natural resources, both renewable and nonrenewable, in order to provide a long-term foundation for population well-being through economic stability and social advancement. Fossil fuel is composed of ancient animal and plant remains. Because fossil fuels are an NREN resource that will decline at some time in the future, and burning them generates GHGs, they cannot be relied on to deliver energy. As a result, reusable REN is necessary. At usual temperatures and pressures, CO_2 occurs in the Earth's atmosphere. Furthermore, CO_2 is a neutral and unscented gas that may be created by any animal, plant, fungus, or bacterium. CO_2 can also be created as a side consequence of burning FF (Sasana & Putri, 2018). Thao (2015) stated that primary cause of GWarm and ClCh is widely acknowledged to be ENU, notably the use of FF. The environmental consequences of such ENU stem not only from ENU but also from the withdrawal process. In the meantime, REN use has a harmful connection with CO_2, implying that growing REN reduces CO_2. Therefore, energy is the primary component of production. As output grows, so does energy consumption.

Empirical Literature

Saidi and Omri (2020) used both FMOLS and VECM estimate methods to examine the SR and LR implications of REN and NEC on CO_2 in 15 OECD nations between 1990-2018. The FMOLS data reveal that: (i) investments in NEC cut CO_2 (ii) Investment in REN decreases CO_2 (iii) Both NEC and REN usage cut CO_2 according to the panel estimates. Furthermore, the VECM method's results suggest that NEC and REN sources minimize CO_2. Their findings indicate that the best way to cut CO_2 is to pursue a combination of NEC and REN. Salari *et al.* (2021) explore the link between CO_2, ENU, and GDPg in the US at the state level from 1997-2016. Their findings indicate a long-term association between various ENU use and CO_2 at the state level. ENU and NREN use all have a positive influence on CO_2, but REN has the opposite effect. The data reveal an inverted-U shape link between CO_2 and GDP, to support the EKC. Huang *et al.* (2021) inspected the bond between REN and CO_2 in a sample of key renewable energy-consuming nations from 2000 to 2015. As a result, the primary contribution of this study was to answer the issue of whether a significant shift toward renewable energy use will result in fewer CO_2 emissions. Their empirical results, obtained using GMM estimator, indicated that REN had a considerable negative influence on CO_2. Like, a 1%age-point upsurge in REN results in a 0.5% reduction in CO_2. Chen *et al.* (2022) use panel data from 97 countries between 1995-2015 to investigate the nonlinear influence of renewable and nonrenewable ENU, as well as economic growth, on CO_2, resilient to cross-section dependency. Their findings show that if countries exceed a specific level of REN, the effect on CO_2 is negative and considerable. This conclusion is resistant to the adoption of an alternative proxy for REN, and it is most applicable to industrialized nations and countries with better institutions.

Khezri *et al.* (2022) analyze 29 Asia-Pacific nations from 2000-2018. The association between the complexity index and CO_2 was studied using panel data models and estimating methods. They found that energy usage, TO, and URB all raise CO_2, but the impacts of urbanization finally faded in LR. Furthermore, they supported the EKC theory, but the economic complexity index skewed the curve. The findings show that economic intricacy in nations affects the effects of economic expansion on CO_2 by increasing production size and energy consumption. On the other side, growing economic complexity thru better energy efficiency has a positive impact on the environment. Rehman *et al.* (2023) investigate the influence of globalization, economic expansion, population increase, REN consumption, and NEC on CO_2 globally using yearly data from 1985-2020. The NARDL approach was used to highlight the links between variables while estimating LR and SR outcomes. Their findings show that in both the SR and LR, negative globalization and GDPg shocks have a positive and negative impact on CO_2. Furthermore, increased population growth has been shown to have a beneficial impression on CO_2, although REN usage has no effect. Finally, there is evidence that both positive and negative shocks to alternative NEC use have a negative impression on CO_2.

Sobczuk *et al.* (2025) assess emissions from operation, manufacture, and disposal, as well as the impact of energy storage schemes. CO_2 from photovoltaic systems range from 28 to 100, depending on manufacturing energy mix and panel efficiency. Wind turbines produce lower emissions, ranging from 7 to 38, depending on the turbine type and operating conditions. Despite minimal operating emissions, renewables have a significant environmental effect, including biodiversity disturbances, changes in land usage, and material recycling issues. The data show that, while renewable technologies dramatically lower CO_2 when compared to fossil fuels, their environmental impact needs integrated sustainability policies. Azizi *et al.* (2025) adopt a comprehensive system dynamics method to evaluate these CO2 emission-reduction initiatives in Iran's electricity generation sector. Their findings reveal that while both strategies improve the country's energy security, the renewable development program has a greater impact on lowering CO_2. Furthermore, the findings revealed that by executing the photovoltaic development program, access to the 21% share of the whole Iranian power sector may be achieved by the end of 2033. Furthermore, enacting an efficiency-enhancing strategy can increase thermal power plant efficiency by up to 3.5%. Bhowmik *et al.* (2025) analyse the effects of hydropower energy (HPE), clean energy financing (FCE), FDI, gross fixed capital formation (GFCF), and renewable REN on CO_2 emissions and environmental sustainability indicators in South Asian countries from 2004 to 2022. The study found that REC has a considerable impact on reducing CO_2 and increasing environmental sustainability. However, HPE and FDI have a positive correlation with CO_2, indicating inefficiencies in energy production and investment. Meanwhile, FCE and GFCF have a minimal association with CO_2 emissions.

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Summary of Literature and Gap

Moreover, the previous scholars also looked at the impact of NREN use on CO_2. Most of these researches employed various econometric approaches to assess the possessions of REN and NEC on CO_2 fall. Though, the findings are conflicting and lacking. Silva *et al.* (2012) investigate the causal link among REN sources and CO_2 and utilized data from 1960-2004 of United States, Spain, Denmark, and Portugal, and reveled that swelling the quantity of REN in the energy mix reduced CO_2 . Al-Mulali *et al.* (2016) discovered that REN use reduces CO_2 in Europe, the Americas, and Asia. Irandoust (2016) presented information indicating that REN reduces CO_2 in four (4) Nordic nations. Dogan and Seker (2016) demonstrated that increasing the usage of REN lowers CO_2 in the leading REN nations.

However, Apergis *et al.* (2010) found that the utilization of REN had little effect on short-term carbon emission reduction. Menyah and Wolde-Rufael (2010) investigated the causal link among REN and CO_2 in the United States between 1960-2007, concluding that REN makes no meaningful contribution to CO_2 emission reduction. Chiu and Chang (2009) discovered that REN will start to reduce CO_2. Al-mulali (2014) discovered that NE has a significant role in reducing CO_2, as it boosts GDPg without increasing CO_2. Baek and Pride (2014) shown that NEC and CO_2 have a harmful LR connection in the US, France, Korea, Japan, Canada, and Spain. NE has a positive influence on CO_2 reduction in Korea, the United States, and 12 (twelve) major nuclear-generating economies. Not at all, Iwata *et al.* (2012) determined that NEC plays only a minor effect in reducing CO_2 in most OECD nations. According to Jaforullah and King (2015), CO_2 in the US are unrelated to NEC use when energy-prices are not taken into account as a potential the driving factor behind ENU. Though several studies have looked at the relationship between REN, nuclear-energy usage, and CO_2, there has been minimal empirical research into the link between overall non-fossil ENU and CO_2 using contemporary econometric techniques. Furthermore, empirical research has mostly fixated on the impression of REN and NEC on CO_2 (Li & Yang, 2016).

Research Methods

Research Nature

This research used the data from 1990-2020 based on the data availability in the case of Pakistan. The data was be composed from World Development Indicators (WDI) (2024).

Table 1: Variables Descriptions

S.No	Variable	Data period	Quantity	Symbol	Source
1	CO_2 emissions (kg per 2015 US$ of GDP)	1990-2020	kg per 2015 US$ of GDP	CO_2	Dogan and Seker (2016), and Fayaz *et al.* (2024)
2	Fossil fuel energy consumption (% of total)	1990-2020	Percentage	NREN	Sun *et al.* (2020) and Chandio *et al.* (2021)
3	Renewable energy consumption (% of total final energy	1990-2020	Percentage	REN	Apergis *et al.* (2010) and Irandoust (2016)

	consumption)				
4	GDP per capita growth (annual %)	1990-2020	Percentage	GDPg	Hanif (2017) and Raza *et al.* (2019)

Conceptual Framework

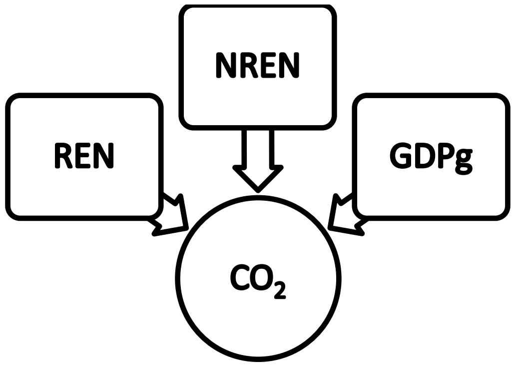

Figure 1: Conceptual Framework

Model Specification

This study used the following reformed model, which is also used by Apergis *et al.* (2010), Azam *et al.* (2024), Fayaz *et al.* (2024) and Azam *et al.* (2023).

$$CO_{2_t} = \beta_0 + \beta_1 NREN_t + \beta_2 REN_t + \beta_3 GDPg_t + \beta_4 GDPg_t^2 + \mu_t \ldots\ldots\ldots\ldots \quad (1)$$

CO_2 stands for carbon emission usage as a proxy for environmental degradation, NREN for non-renewable energy use, REN for renewable energy use, and GDPg for economic growth (GDPg).

Turning Point

$$\boldsymbol{GDPg_t} = \frac{-\beta_3}{2\beta_4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Estimation Techniques

The data behavior is observed through unit root tests. The ARDL fitting for assortment order of integration and give precise result in small samples (Pesaran & Shin, 1995).

The Model in ARDL form

$$CO_{2_t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i} CO_{2_{t-i}} + \sum_{i=0}^{n} \beta_{2i} NREN_{t-i} + \sum_{i=0}^{n} \beta_{3i} REN_{t-i} + \sum_{i=0}^{n} \beta_{4i} GDPg_{t-i} + \sum_{i=0}^{n} \beta_{5i} GDPg^2{}_{t-i} + \mu_t \ldots\ldots\ldots\ldots \quad (3)$$

The Model in ARDL-Bound form

$$\Delta CO_{2_t} = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta CO_{2_{t-i}} + \sum_{i=0}^{n} \beta_{2i} \Delta NREN_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta REN_{t-i} + \sum_{i=0}^{n} \beta_{4i} \Delta GDPg_{t-i} + \sum_{i=0}^{n} \beta_{5i} \Delta GDPg^2{}_{t-i} + \gamma_1 NREN_t + \gamma_2 REN_t + \gamma_3 GDPg_t + \gamma_4 GDPg^2{}_t + \mu_t \ldots\ldots\ldots\ldots \quad (4)$$

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Results and Discussions

Table 2 present the summary of imaginative statistics, this shows that the series $NREN_t$ have the highest, while; CO_{2t} has the lowest mean and standard deviation. Furthermore, all the series are normally distributed. Moreover, the CO_{2t} is negatively correlated with $NREN_t$ and $GDPg_t$, while positively correlated with REN_t.

Table 2: Descriptive Statistics Results

Variables	CO_{2t}	$NREN_t$	REN_t	$GDPg_t$
Mean	0.5690	55.127	48.565	1.694
Median	0.5774	57.083	47.650	1.446
Max	0.6335	62.476	58.100	5.448
Min	0.5068	42.573	41.600	-2.9703
Std. Dev.	0.0332	5.8082	4.477	2.168
Skewness	-0.1235	-0.7828	0.3513	-0.048
Kurtosis	2.0116	2.3831	2.3306	2.396
Jarque-Bera	1.4703	4.0113	1.334	0.529
Probability	0.4794	0.1346	0.5132	0.767
CO_{2t}	1			
$NREN_t$	-0.1630	1		
REN_t	0.1320	-0.9331	1	
$GDPg_t$	-0.0902	0.1622	-0.1596	1.0000

Unit Root Results

Table 3 present the ADF test results, this shows that CO_{2t}, NRENt and RENt have 1st while, GDPgt has zero order of integration.

Table 3: ADF Test Results

Variables	At level		At first Difference		Decisions
	t-Stat	Prob.*	t-Stat	Prob.*	
CO_{2t}	-2.242239	0.1960	-5.996256*	0.0000	Stationary at 1st difference
$NREN_t$	-2.542613	0.1150	-4.784880*	0.0005	-do-
REN_t	-1.712297	0.4160	-5.199533*	0.0002	-do-
$GDPg_t$	-4.067451*	0.0034	----	----	Stationary at level

*Note: * shows the significance level at 1%.*

Regression Results

Table 4 presents the ARDL results, in the LR, this shows that the NREN has positive and substantial effect on CO_2. A present change in the NREN will increase the CO_2 by 0.008 present, on average. However, the REN has negative and substantial effect on CO_2. A present change in the REN will decrease the CO_2 by 0.018 present, on average. However, the GDP growth has optimistic and significant effect on CO_2. A present change in the GDPg will increase the CO_2 by 0.006 present, on average.

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The past studies also found that GDPg and ENU have a positive relationship in the top 10 ENU nations (Mohsin, Abbas, *et al.*, 2019; Shah *et al.*, 2019; Sun *et al.*, 2019; Tang *et al.*, 2016; Yildirim *et al.*, 2012). Shahbaz *et al.* (2012) examined the relationship between ENU and GDP by evaluating data from the top ten (10) ENU nations. Furthermore, energy usage is a key driver of GDPg in the top ten (10) ENU nations. Ozcan and Ozturk (2019) investigated the relationship between energy consumption and GDPg in China. Their findings revealed that in China, GDPg is mostly dependent on ENU. Liu and Hao (2018) discovered the bond between EC and GDPg. Their findings revealed a LR bi-directional link between GDPg and ENU in emerging Asian nations. For example, Tang and Abosedra (2014) examined the link among GDPg and ENU using data from twenty-four MENA nations. They stated that energy has a significant influence on GDPg (Mohsin, Rasheed, *et al.*, 2019; Mohsin *et al.*, 2021; Mohsin, Zhang, *et al.*, 2019). Sghari and Hammami (2016) examined panel-data from 58 nations and found that GDPg and EC had an encouraging impact on greenhouse gas emissions. Furthermore, Lin and Benjamin (2017), Omri (2013), and Farhani (2013) found that GDPg and ENU are the primary contributors to GHG emissions. Furthermore, Raza *et al.* (2019) inspect the impression of ENU on GHG in the United States. According to their results, ENU and GDPg are the leading roots of GHG and challenges to CO_2. As a result, over use of NREN degrades CO_2 in the US. Hanif (2017) used data from fifteen growing Asian nations to inspect the impact of GDP and NREN consumption on GHG. They initiate that the use of NREN and GDPg has increased CO_2 (Alemzero *et al.*, 2021; Asbahi *et al.*, 2019; Chandio *et al.*, 2021; He *et al.*, 2020; Mohsin *et al.*, 2018; Mohsin, Zhang, *et al.*, 2019). Furthermore, most studies on the link between ENU and CO_2 have employed linear models, which do not accurately depict the complicated relationship (Sun *et al.*, 2020).

In the short run (SR), this shows that the NREN has optimistic and substantial effect on CO_2. A present change in the NREN will increase the CO_2 by 0.008 present, on average. However, the REN has adverse and substantial effect on CO2. A present change in the REN will decrease the CO_2 by 0.018 present, on average. However, the GDPg has positive and substantial effect on CO_2. A present change in the GDPg will increase the CO_2 by 0.003 present, on average. The ECM value shows that there are 18% sped of adjustment from short to LR-equilibrium. Moreover, there exists LR co integration among the variables. The results also confirmed the EKC in case of Pakistan and its turning point of EKC is 1.55%.

Table 4: ARDL Results

Variable	**Coefficient**	**Std. Error**	**t-Stat**	**Prob.***
$NREN_t$	0.0081*	0.0022	3.6851	0.0036
REN_t	-0.0177*	0.0031	-5.7354	0.0001
$GDPg_t$	0.0057**	0.0019	3.0122	0.0118
$GDPg^2_t$	-0.0010**	0.0004	-2.3194	0.0406
C	0.1024	0.4321	0.2369	0.8171
$D(NREN_t)$	0.0081*	0.0018	4.5518	0.0008
$D(REN_t)$	-0.0177*	0.0015	-11.9961	0.0000
$D(GDPg_t)$	0.0030**	0.0012	2.4860	0.0303
$D(GDPg^2_t)$	-0.0010*	0.0003	-3.4236	0.0057
ECM_{t-1}	-0.1789*	0.0192	-9.3027	0.0000
F-Bounds Test		H_0: No levels bond		
Test Statistic	Value	Sign if.	I(0)	I(1)

F-stat	9.9161*	5%	2.56	3.49
K	4	1%	3.29	4.37

Note: * and ** *shows the implication level at 1 and 5%.*

Normality Test Results

Figure 1 presents the JB test results; this shows that the residuals are normally distributed.

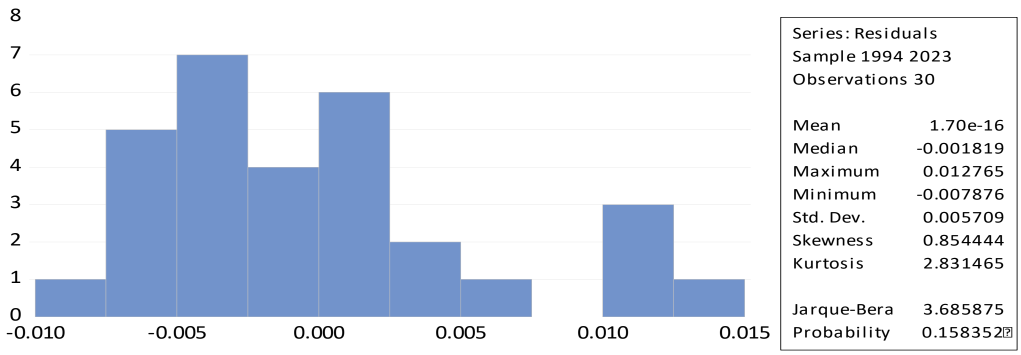

Figure 1: JB test Results

Diagnostic Tests

There is no issue of heteroskedasticity, no serial correlation and specification in the data.

Table 5: Diagnostic Tests Results

Tests with H_0	Statistics	Value	p-value	Decision
Breusch-Godfrey (B-G) Serial Correlation LM Test **H_0: No serial-correlation**	F-statistic	0.1538	0.8596	Sustain H_0
Heteroskedasticity Test: Breusch-Pagan-Godfrey **H_0: Homoskedasticity**	-do-	0.4307	0.9456	-do-
Ramsey RESET Test	-do-	2.1843	0.1702	-do-
H_0: No Specification error in the model.	t-statistic	1.4779	0.1702	

Stability-Tests Outcomes

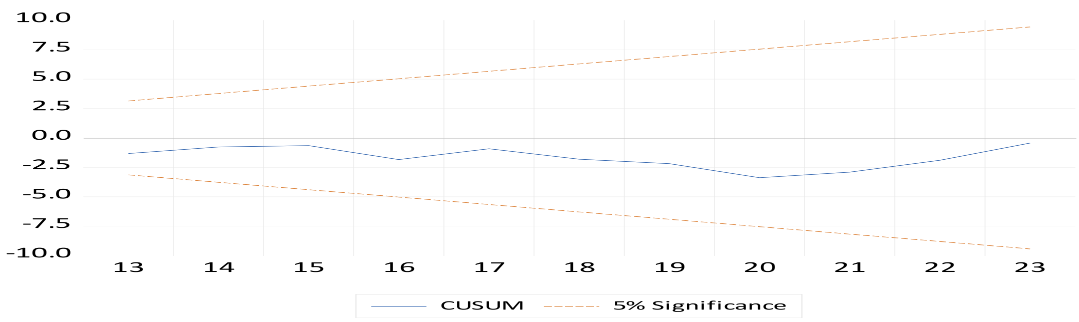

Figure 2: CUSUM test Results

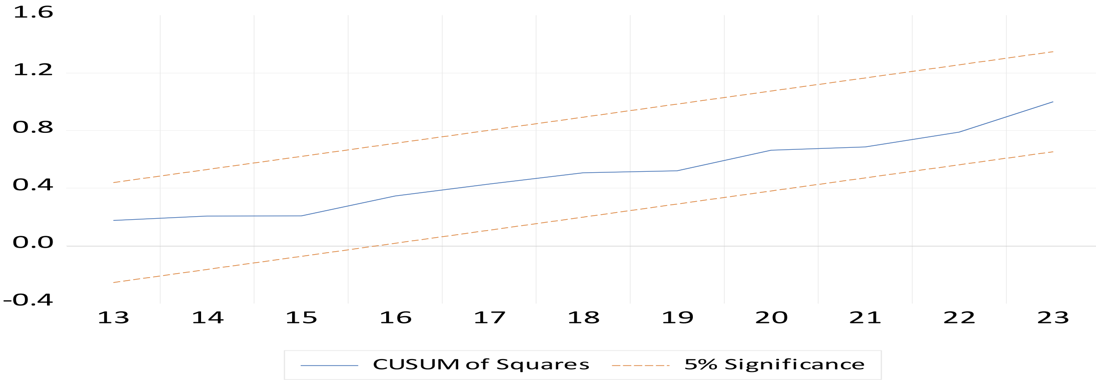

Figure 3: CUSUMOS Results

Conclusion

The primary goals of this research are to analyze the impact of EC on environmental deterioration and to test the EKC in Pakistan. This research examines data from 1990 to 2020 and uses ARDL methods for estimate. This study discovered that in LR, nonrenewable energy and GDP growth had a positive and substantial influence on CO2. Yet, REN has a adverse and large impression on CO_2. Similarly, in SR, this demonstrates that nonrenewable energy and GDP growth have a positive and considerable impact on CO_2. However, renewable energy has a negative and large impact on CO_2. The ECM results indicate that there is an 18% rate of tuning from SR to LR equilibrium. The data also validated the EKC in Pakistan, with 1.55% being the tipping point. It is advised that the government prohibit NREN and support the REN for household and commercial purposes in order to reduce CO_2 in Pakistan and other developing nations. Furthermore, the government must boost economic growth after reaching a tipping point in order to minimize CO_2 in Pakistan and other developing nations. This study's findings contribute to increased productivity while minimizing environmental impact. Due to time restrictions, this study only employed data from Pakistan; however, other nations or groups of countries might be used to provide more solid findings.

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