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The Effect of Non-Renewable and Renewable Energy Consumption on CO2 Emissions: Evidence from Pakistan

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ABSTRACT

Concerns over the harmful consequences of climate change and global warming have grown since the 1990s. The primary subjects of discussion when it comes to climate change are energy production and consumption, as burning fossil fuels is the primary purpose of greenhouse gas emissions. Furthermore, using fossil fuels to produce commodities endangers human health and contributes to environmental damage. Clean, sustainable energy sources that are abundant in the natural world and do not pollute the air are becoming more and more important to modern cultures. This study looks at the long-run relationship between CO2 (carbon emissions) in Asian countries between 1990 and 2021 and the utilization of non-renewable and renewable energy sources. The significance of renewable energy sources and their impact on CO2 emissions are the main points of emphasis. According to the data, using nonrenewable energy sources causes CO2 emissions to increase, while using renewable energy sources causes them to decrease. CO2 (carbon emissions) and economic growth are positively correlated; as growth picks up speed, so do emissions. Furthermore, the square of economic expansion produces the opposite effect, lowering emissions of carbon dioxide. This observation lends credence to the Kuznets theory. Moreover, even though foreign direct investment has the opposite effect, the rate of urbanization is one of the reasons of the rise in CO2 (carbon emissions).

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1. Introduction

The issue of global warming and climate change has been around for more than 20 years. The IPCC (Intergovernmental Panel on Climate Change) formally acknowledged in 1995 that there was sufficient evidence to conclude that human movement was causing global

warming. Nevertheless, this line of thinking acknowledged a range of questionable and uncertain deductions, thereby leading to the provisional nature of these findings (Sahoo & Sahoo, 2022). However, as indicated by recent research conducted by the IPCC (2014) , the increase in greenhouse gas (GHG) concentrations and various human movements are contributing to the phenomenon of global warming. Some researchers have determined that the two primary factors contributing to the increase in greenhouse gas (GHG) emissions are expanding industrial expansion and rising power consumption. For a while now, observers and policymakers have been closely monitoring the relationship between growth of economy, greenhouse gas emissions, and use of energy. This issue has progressively evolved into a major global concern. Subsequently, countries pledged to progressively decrease environmental pollution based on the most comprehensive research and strive for sustainable development and efficiency, recognizing the need to achieve sustainable economic growth (COP, 2016).

The substantial role that CO2 emissions has played in recent decades in contributing to global warming and climate change puts the ecosystem's long-term health at danger (Bölük & Mert, 2014; Shayanmehr, Rastegari Henneberry, Sabouhi Sabouni, & Shahnoushi Foroushani, 2020). Ninety percent of CO2 emissions in the world are caused by burning fossil fuels, according to research from the JRC (Joint Research Centre) of the European Commission (Olivier, 2012; Shayanmehr et al., 2020). Fossil fuels have historically been crucial to the growth of national economies, as demonstrated by GDP, despite mounting concerns about rising CO2 emissions levels and their ability to contribute to climate change (Pirlogea & Cicea, 2012). Some people think that using renewable energy can help strike a balance between environmental quality and economic progress. As a result, many nations have a strong incentive to continue advancing renewable energy. As Lee (2005) points out, using renewable energy has been seen as a powerful way to reduce CO2 (carbon emissions) and achieve SDG's.

The problem of climate change caused by greenhouse gas emissions extends beyond industrialized nations. In 2011, China and India, two developing countries, were estimated accountable for 62 percent of the global CO2 emissions. Every government, particularly emerging countries with low carbon efficiency, should carefully assess the potential negative impact on economic growth when contemplating the amount to which they could decrease CO2 emissions by reducing fossil fuel consumption (Ito, 2017). Several empirical studies have looked into the connection between overall energy use and economic expansion. Among the studies that have been mentioned are (Akinlo, 2008; Eggoh, Bangaké, & Rault, 2011; Haq, Nawaz, Akram, & Natarajan, 2020; Joyeux & Ripple, 2011; Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Ouedraogo, 2013). Research has not focused much on the link between nonrenewable and renewable energy use with CO2 emissions. Apergis and Payne (2009) support their hypothesis that use of energy and CO2 emissions have a causal relationship that operates in both directions using panel data from 1971 to 2004 in encompassing six Central American countries. Apergis and Payne (2009) support their argument that there is a positive relationship between use of energy growth of economy by providing panel data from 1992 to 2004 for 11 Common Wealth countries. Additionally, the researchers have shown that emissions and energy demand are causally related. Similar to this, Apergis and Payne (2009) used data from 13 Eurasian countries to show a reciprocal association between the adoption of renewable energy and growth of economy.

This research aims to investigate the variables that influence CO2 emissions, specifically the utilization of nonrenewable and renewable energy sources, and ascertain the proportionate roles played by each in the contamination of the environment in developing Asian nations. Quantile regression was used in this study because it has benefits including being insensitive to distant or out-of-date data and being able to estimate a variable more accurately based on its unique distribution. This specific group of emerging countries was selected because of their higher emissions of pollutants compared to other nations worldwide, primarily resulting from their heavy reliance on fossil fuels, which has detrimental effects on the environment.

Furthermore, a majority of global pollution caused by carbon dioxide discharges. The effects of energy use, from both non-renewable and renewable sources, on developing Asian countries have been assessed in this study.

2. Reviews of Literature

Sargolzaiea and Ghasemib (2022) investigate how use of energy-both nonrenewable and renewable-affects CO2 (carbon emissions) in the Asian region. Data from 1965to2019 were examined in the study using the panel data approach. According to the results, utilizing renewable energy sources lowers CO2 (carbon emissions) while using nonrenewable energy sources increases CO2 emissions.

Dahri et al. examined 25 developing Asian nations and the results of switching from renewable to non-renewable energy in research published in 2021. To investigate this shift, the researchers employed HTR (Hausman-Taylor Regression) and the RRE (Robust Random Effect) approach. The findings show a strong and favorable correlation between use of energy and growth of economy.

Vinh Vo et al.'s 2020 study looked at the connection between economic expansion and the consumption of renewable energy. The data set for the study included all of 1990 through 2018. Heterogeneous non-causality approaches, FMOLS (fully modified ordinary least squares) and DOLS (dynamic ordinary least Sargolzaiea and Ghasemib (2022) squares are used in the research. According to the research, labor, capital, non-renewable energy and renewable energy all have a favorable effect on growth of economy.

Khan (2020) examined the relation between use of energy, growth of economy and CO2 (carbon emission) in Pakistan by utilizing annual timeseries data spanning from 1965 to 2015. The ARDL's results show that rising use of energy and economic expansion share equal responsibility for the rise in CO2 emissions.

An empirical study by Belaïd and Zrelli (2019) looked into the relationship growth of economy, carbon emissions, and the use of nonrenewable and renewable energy sources. In use from 1980 to 2014 were nine Mediterranean countries. We examine the log and short-run dynamic interactions while taking cross-sectional dependency and heterogeneity into account, using the PMG panel ARDL and panel econometric approaches. The findings suggest that the utilization of renewable energy sources, GDP, and CO2 (carbon emissions) have a short-term reciprocal causal link. Moreover, there is the causal relationship between the GDP, the amount of power generated from non-renewable sources, and the renewable energy use. The results show that the use of non-renewable electricity and CO2 emissions have a long-term, reciprocal causal link.

Shahbaz, Zakaria, Shahzad, and Mahalik (2018) looked at the relation between GDP growth and use of energy. They apply the Quantile-on-Quantile Approach to assess the newly found evidence. The findings exhibit a robust association between economic expansion and energy usage, with notable fluctuations noted in connection to the distinct economic circumstances in every nation.

Zaidi, Danish, Hou, and Mirza (2018) looked into the connection between using renewable versus nonrenewable energy while operating a vehicle and CO2 emissions. The results demonstrated that utilizing more renewable energy lowers carbon dioxide emissions. At the associate degree level, the researchers used the ARDL model. The results show that, in the renewable energy model, growth of economy significantly affects CO2 petrol emissions, but not in the nonrenewable energy model.

Jian, Fan, He, Xiong, and Shen (2019) conducted research in Beijing to look into the connections between economic development, transportation, and environmental degradation. They used data from 1995 to 2014 to perform econometric study. The findings show that CO2 emissions and mobility have positively effects on growth of economy.

The link between India's CO2 emissions, growth of economy and energy consumption (coal, oil, gas, and electricity) was thoroughly and comprehensively analyzed by Ahmad et al. (2016). The ARDL and VECM models were used in the study, which looked at data from 1971 to 2014. Their findings demonstrate a positive feedback loop between growth of economy and CO2 (carbon emissions) in addition to a direct association between use of energy and CO2 (carbon emissions).

The study conducted by Bhattacharya, Paramati, Ozturk, and Bhattacharya (2016) examines the effect of renewable energy use on the economies of the world's leading nations. Panel estimating techniques were employed in the study to assess data spanning from 1991 to 2012. The results of long-term output techniques demonstrate that the consumption of renewable energy significantly and favorably affects economic productivity.

The link among CO2 (carbon emissions) and the amount of nonrenewable and renewable energy consumed in OECD countries was examined by Shafiei and Salim (2014) In this study the STIRPAT model was utilized by the researchers to examine data spanning from 1980 to 2011. According to their findings, utilizing non-renewable energy has a positive effect on CO2 (carbon emissions) whereas negative impact of using renewable energy.

In their 2013 study, Alkhathlan and Javid (2013) examined the connection between Saudi Arabia's economic expansion, energy usage, and greenhouse gas emissions from 1980 to 2011. The inquiry evaluated this relationship from a wide and comprehensive perspective. The results show that income per capita and CO2 emissions are positively correlated. The study also shows that rising carbon dioxide emissions are a findings of increased energy use, more especially the use of aggregate, gas, electricity, and gas and oil. Moreover, studies indicate that increased energy use stimulates economic expansion.

In their research, Shahbaz, Solarin, Mahmood, and Arouri (2013) investigated the effect of energy use from biomass on emissions of carbon dioxide (CO2) in eighty countries, comprising both developed and developing nations. The Gaussian Mixture Model (GMM) method was utilized by them. The results show that while the use of hydroelectricity has not significantly increased CO2 emissions, the consumption of fossil fuels and biomass energy has. Furthermore, it has been seen that increases in population, urbanization, and real GDP all contribute to higher CO2 emissions. Nonetheless, research has also shown that a high standard of institutional excellence lowers carbon dioxide emissions. These findings suggest that while trade openness, FDI, and financial expansion reduce emissions in wealthy nations, they have the opposite effect in developing nations.

Alam, Begum, Buysse, and Van Huylenbroeck (2012) assess the causal link between use of energy, income, and carbon dioxide emissions using a multivariate model. For India, data from 1971 to 2006 was used. It was shown that energy use and CO2 (carbon emissions) had a long-run reciprocal relationship. Their results disprove the idea that energy, CO2, and real income are causally related.

Menyah and Wolde-Rufael (2010) looked at the connections between US growth of economy, nuclear power, renewable energy, and CO2 (carbon emissions). The study, which was based on the Muslija, Šatrović, and Čolaković (2020) exam, looked at data from 1960 to 2007. The results demonstrate the damaging effects that non-renewable resources have on the ecology. Utilising sustainable energy sources has been demonstrated to significantly correlate with CO2 emission.

3. Theoretical Background

The relationship between various EKC (Environment Kuznets Curve) and income per capita is believed to be represented by an EKC (environmental Kuznets curve). Grossman and Kruger first introduced this idea in their well acclaimed empirical investigation in 1991. Research has demonstrated that there is a negative U-shaped correlation between economy expansion and environment degradation. Metrics like per capita GDP and CO2 emissions show an inverse Ushaped relation between economy behavior and environment quality, which is consistent with the hypothesis of EKC. The graphic in Figure 1 shows the U-shaped pattern of the EKC (Environmental Kuznets curve).

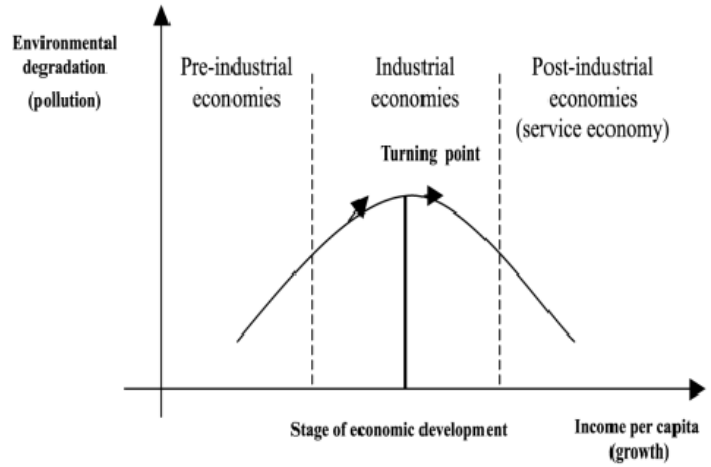

Figure 1: EKC (Environmental Kuznets Curve)

So, in the First Period Growth of economy, Environment Degradation will enlarge with an increment in Income Per Capita, and begin to diminish as an increase in Income Per Capita proceeds ahead of the Turning Point of Income.

4. Data and Methodology

Utilizing yearly time series data spanning from 1990 to 2021, the research assessed how Pakistan's CO2 emissions were impacted by renewable and nonrenewable sources. There are numerous variables in the data. The following equation can be used to determine the study's model:

$$CO_2 = f(RE, NRE, GDP, GDP^2, FDI) \quad (1)$$

The econometric model of the study can be estimated by the following equation:

$$CO_2 = \beta_0 + \beta_1 RE_{it} + \beta_2 NRE_{it} + \beta_3 GDP_{it} + \beta_4 GDP^2_{it} + \beta_5 FDI_{it} + €_{it} \quad (2)$$

The environment is represented by CO2, renewable energy is by RE, non-renewable energy is by NRE, and the EKC (Environmental Kuznets Curve) theory uses GDP and GDP2. FDI stands for Foreign Direct Investment. The study's estimated model is informed by the Literature Reviews and the Theory of Environmental Kuznets Curve (EKC).

4.1. Measurement of Indicators

Table 1 provides a description of the indicators employed in the current investigation, including their abbreviations and measurement units.

Table 1

Indicators Description

Indicators	Explanation	Units
(CO_2)	Carbon Dioxide Emission	Thousand Ton (kt)
(RE)	Renewable Energy	% of Total Consumption
(NRE)	NonRenewable Energy	% of Total Consumption
(FDI)	Foreign Direct Investment	Inflow, % of GDP
(GDP)	Gross Domestic Product	Annual Growth
(GDP^2)	Square of Gross Domestic Product	Annual Growth

Source: World Bank

4.2. Data Type and Sources

This study assessed how Pakistan's CO2 emissions were affected by renewable and non-renewable sources using annual data from 1990-2021. Among the many sources from which the data is gathered are the IREA (International Renewable Energy Agency) and the WDI (World Development Indicators).

5. Data Analysis and Results Interpretation

5.1. Analysis of Multicollinearity

The existence of a precise linear relationship between one or more explanatory indicators in a regression model is referred to as multicollinearity. When multicollinearity occurs between variables, the Pair-Wise Correlation Matrix is usually used to identify the problem.

Table 2

Correlation Matrix

Variables	LCO_2	RE	NRE	GDP	GDP^2	FDI
LCO_2	1.000000					
RE	-0.016728	1.000000				
NRE	0.569087	-0.110173	1.000000			
GDP	0.112957	0.069011	0.062853	1.000000		
GDP^2	0.196809	0.087914	0.140597	0.727908	1.000000	
FDI	-0.673026	-0.101200	-0.424976	-0.135099	-0.259299	1.000000

Source: Software Eviews-9

Table 2 above, displays the results of the Pair-Wise Correlation Matrix. It demonstrates that high values indicate a strong association among variables. The overall results indicate that there is no presence of multi-collinearity in the dataset.

5.2. Analysis of Autocorrelation

The issue of Autocorrelation occurs when there is a correlation between consecutive error words. The issue of Autocorrelation is addressed by the utilization of the Serial Correlation Breusch-Godfrey LM test. The table below presents the results of the Serial Correlation LM test, as seen in Table 3:

Table 3

Serial Correlation Breusch-Godfrey LM Test

F-Statistics	2.438429	**Prob. F (2,17)**	0.4449

The results indicate that the probability values of the LM test are not statistically significant (0.4449), suggesting that there is no evidence of autocorrelation in the data set.

5.3. Analysis of Heteroskedasticity

Heteroskedasticity refers to a condition in which the variability of the errors or residuals is not constant across different levels of the measured values. The issue of Heteroskedasticity is addressed through the utilization of the Breusch-Pagan-Godfrey Test in Table 4:

Table 4
Heteroskedasticity Test

F-Statistics	8.363306	**Prob. F (8,17)**	0.8259

The findings suggest that probability values of the Heteroskedasticity test are not significant (0.8259), indicating that there is no presence of Heteroskedasticity in the dataset.

5.4. Empirical Results

Table 5
Ordinary Least Square

Dependent Variable: Log of CO_2
Method: Ordinary Least Square
30 observations used for estimation from 1990 to 2021

Variables	Coefficient	Standard Error	T-Statistic	Prob.
RE	-0.118650	0.036286	-3.269902	0.0043
NRE	0.008561	0.003284	2.606736	0.0178
GDP	0.001907	0.001462	1.304753	0.0284
GDP^2	-0.000406	0.008271	-0.491485	0.0690
FDI	-0.018197	0.001324	-1.374654	0.0000
$LCO_2(-1)$	0.963043	0.247921	3.884478	0.0009
C	5.250884	0.339316	15.47492	0.0000
R^2	0.983559		Adjusted R^2:	0.977165
F-Statistics	153.8327		Prob.(F-Statistic):	0.000000
Durbin-Watson stat	1.928615			

The coefficient of Renewable Energy in Table 5 demonstrates a large and detrimental effect on the environment. The data suggests that for every one-unit rise in Renewable Energy, there is a corresponding loss of -0.118650 in the Environment. The environment is positively and statistically significantly impacted by the non-renewable energy coefficient (Baloch et al., 2021; Hanif, Nawaz, Hussain, & Bhatti, 2022). The study indicates that a one unit increase in renewable energy will result in a 0.008561 benefit in the environment. GDP2 has a detrimental effect on the environment, but the GDP coefficient indicates a positive correlation. This graph shows the inverse U-shaped link between growth of economy and CO2 (carbonemissions). The existence of the EKC (Environmental Kuznets Curve) Hypothesis in Pakistan was supported by this research. The value of coefficient of FDI exhibits a statistically significant and negatively influence on the environment. FDI stimulates economic growth by fostering capital creation and enhancing productivity through the transfer of management expertise, technological know-how, and knowledge. This leads to the modernization of the economy through innovations and technology. Foreign Direct Investment (FDI) reduces carbon dioxide (CO2) emissions by implementing cleaner technologies to optimize the production process and by making investments in the research and development sector.

6. Conclusion and Policy Recommendations

This study's primary goal is to interrogate how Pakistan's CO2 emissions are impacted by both renewable and non-renewable energy sources. This research made use of Pakistan's Annual Time Series Data, which was collected from multiple databases and covered the years

1990 to 2021. The results of the study were obtained using the Ordinary Least Square (OLS) method. The empirical evidence makes a number of important discoveries. Reducing carbon dioxide emissions (CO2) in Pakistan is directly impacted by GDP2, FDI, and renewable energy consumption. Furthermore, growing GDP and non-renewable energy use lead to increased emissions of carbon dioxide (CO2). Further proof that the EKC (Environmental Kuznets Curve) theory is valid in Pakistan is provided by the research.

The current study provides policy recommendations based on the findings. Pakistan must promptly adopt and oversee environmental legislation to utilize clean and eco-friendly technology for industry. To enhance environmental quality, it is crucial to closely monitor the technology that foreign direct investment (FDI) brings in. Green technology innovation and the use of renewable energy sources are effective means to reduce CO2 emissions, serving as a widely recognized measure of sustainable development. Consequently, substantial allocation of resources towards green technologies and renewable energy sources, along with meticulous control of economic activities, can aid Pakistan in mitigating its CO2 emissions. Pakistani governments should increase their investment in eco-friendly technological breakthroughs. Furthermore, it is imperative to promote the use of sustainable energy in both commercial and residential sectors through the implementation of incentives, such as financial support and reduced prices, for renewable energy sources. This approach aims to address the issue of environmental degradation. Reducing the consumption of fossil fuels has significantly contributed to the region's tourism growth and economic development. To preserve Pakistan's environmental quality, the government and energy policymakers should embrace alternate and clean energy systems, including renewable and other alternative energy sources.

Authors' Contribution:
Rabia Islam: Writing Draft, Review of Literature, Conceptualization
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Sundas: Data Curation, Editing
Ali Hassan: Data Analysis and Interpretations
Sidra Shaukat: Revising the Draft & and Editing

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