Abasyn Journal of Social Sciences
Vol (14), Issue (2), 2021.
Open Access
DOI:
10.34091/AJSS.14.2.06

Modelling CO^2 Emissions, Economic Growth and Electricity Consumption Nexus in Pakistan: Evidence from Cointegration and Causality Analysis

Umer Qazi
Abasyn University Peshawar

Abstract

Climate change debates have mainly focused on CO^2 (carbon dioxide) emissions from fossil fuels. These emissions are both hazardous and complicated. The challenge of satisfying rising energy demand while also decreasing CO^2 emissions has become critical in many parts of the world. Using the ARDL approach and Toda Yamamoto Granger causality, this work estimates Pakistan's CO^2 emissions from non-traditional and traditional sources between 1971 and 2017. According to the findings, gross domestic product, population, and conventional energy sources all lead to a rise in CO^2 emissions, whereas hydropower contributes to reducing emissions. Finally, a causation study established a link between economic growth and CO^2 emissions, as well as fossil-fuel-generated electricity and CO^2 emissions in the atmosphere. Traditional electricity sources were found to have a one-way causality towards CO^2 and a neutrality effect on both hydel electricity and CO^2. More people means a growth in demand for energy/electricity, which boosts economic activity and, as a result, increases carbon intensity. However, employing greener energy solutions could help lower greenhouse emissions. Some specific policy recommendations are made in response to the major findings.

Keyword: *CO^2 emissions, GDP, Energy consumption, ARDL, Toda Yamamoto Causality*

Pakistan is a South Asian developing state with a rapidly growing economy and trends indicate that this economic growth will further flourish at the same pace (Sheikh, Shahzad, & Ishak, 2016). An "Eco-System Restoration Fund" has just been formed in Pakistan to assist nature-based solutions to climate change and adopt changes to ecologically robust activities, including plantation and wildlife protection. Over 7,300 km² of land will be conserved and 5,500 green employment will be created as a result of this project, which includes 15 protected areas across the country. When it comes to environmental concerns that Pakistan is dealing with, it would be a huge opportunity for Pakistan to show off its achievements. There will be a great deal of potential for the government to get larger economic, technological and organizational help from the international organizations during this event. Pakistan's endeavours to project its national wealth are putting it on the map of the world. There is a chance to turn the bubbling (environmental) weaknesses into strengths by attending this event. To prevent these threats from completely disrupting the growth path, the government must undertake an active strategy and practical measures. According to experts, despite recent progress in environmental protection, the country still faces significant challenges. In the face of everything from uncontrolled urbanisation and pollution to deforestation and marine encroachment, we have the answer. For Pakistan, it would be a long time before environmental issues, which are harming the country's economy, such as conventional use of energy, industrialization, health and agriculture, can be blocked (Anadolu Agency, 2021).

In the past agriculture sector was the main contribution to Pakistan's economy, but in past few years, the share of this sector is decreased due to industrialization. The other factor due to which this sector is suffering is the cutting of agricultural land which also causes severe environmental issues in the shape of global warming, deforestation, and fall of natural resources (Hayat, Nadeem, & Jan, 2019). The mass production of industries from conventional energy resources as well growth in the economy is causing a high level of CO^2 emissions in Pakistan (Khan, Khan, & Rehan, 2020; Wolde-Rufael & Menyah 2010). According to the study of Yang and Li (2017), the enormous amount of greenhouse effect has caused environmental degradation and causes severe health issues (Zeshan & Ahmed, 2013). CO^2 emanation has a disparaging impact on the economy and related sectors (Shahbaz *et al.*, 2013). Researchers have discovered a link between economic growth, energy usage, and environmental protection, and most of these studies were carried out in advanced countries like Europe and the United States of America (USA). The result of these studies found that with the development of the economy the level of energy consumption is also boosted which in return causes mass CO^2 emissions (Chaudhry, 2010; Pao & Tsai, 2010; Siddiqui, 2004; Kasman & Selman 2015). Economic expansion, conventional forms of energy, and Emission factors must be examined in conjunction to recognise and refine Pakistan's growth patterns (Qazi et al., 2021). Nations that are rich in natural resources can offset the emissions of CO^2 by reducing the use of conventional energy sources (Balsalobre *et al.,* 2018).

Problem Statement

Urban Population and GDP per capita growth have surged rapidly in several developing countries over the past decade. A resurrection of financial development has been driving rapid urbanisation and industrialization of developing markets since the 1970s. As carbon fuels usage and Carbon intensity continue to rise, so do these procedures. The following are some of the study's contributions to the body of knowledge: First the current study follows up on previous research and adds a few more variables to the CO2 framework in Pakistan for more robust policy inferences in the country. Secondly, although prior studies like (Tang & Tan, 2015; Shahbaz, et al., 2015; Salahuddin et al., 2015) incorporated FDI inflows and financial development predictors via various economic settings respectively, none of the studies added Population, and disaggregated energy consumption with growth in the economy to probe the impact on CO2 emissions in a large panel setting for Pakistan. A recent study for Pakistan was done by (Baig & Baig, 2021), which incorporated the population factor but used aggregate energy variable. Finally, the traditional unit root tests, such as the ADF, DF-GLS, and PP tests, have the drawback of not accounting for the potential of a structural break. According to Waheed et al. (2006), Perron demonstrated that the capacity to reject a unit root reduces when the stationary alternative is valid and a structural break is overlooked, assuming the time of the break as an exogenous factor. In a version of Perron's original test, Zivot and Andrews assume that the exact moment of the break-point is undetermined. Rather, to calculate the breakpoints, a data-dependent algorithm is utilised to simulate Perron's subjective approach.

The link between co2 emission and the differentiated use of energy in Pakistan has not been thoroughly investigated. Even though Pakistan is not a developed country, environmental pollution is expected to become a major problem, and a strong national policy is needed to ensure that environmental management can proceed smoothly. Consequently, our study implication is that adequate social sector investments, particularly for the environment, are critical to overcoming the serious challenges of air, water and land pollution.

In light of the foregoing considerations, here the objective of the study is to examine the relationship between population, disintegrated energy consumption, growth, and Carbon dioxide emission in Pakistan. Many studies studying the time series data have used techniques and different techniques as the OLS and many other co-integrating techniques. Engle-Ganger and Johansen (1988) and Johansen-Juselius (1989) co-integration techniques both measure the long-run association among the different variables that did not incorporate the series with the unit root. As we have data set that is a mix and a combination of the stationary and the non-stationary data the ARDL approach proposed by Pesaran et al. (1997) gives unbiased and efficient estimators. ARDL approach provides freedom from the problem of autocorrelation and endogeneity (Pesaran et al., 2001). The autoregressive distributed lag (ARDL) model is incorporated for estimation. ARDL is the mainstay of vibrant single equation regression analyses. The error correction model (ECM) in ARDL is one of the most interesting re-parameterization. Whereas other cointegration approaches require a similar order of the combination, the ARDL model can be used when the variables are stationary at similar or different levels. Moreover for dependent and regressing variables choosing different lag lengths is not an issue (Pesaran et al., 2001).

Research Questions

1. Is there any cointegration and causality between CO^2 and GDP?
2. Is there any cointegration and causality between CO^2 and Population?
3. Is there any cointegration and causality between CO^2 and non-renewable energy sources?
4. Is there any cointegration and causality between CO^2 and Hydel energy sources?

Literature Review

For any nation to achieve higher economic performance and infrastructure, the abundance of natural resources does keep great importance as it spurs the growth of the economy and in return improves the overall living standards of a nation (Khan, 2021). According to the study of Osobajo, Otitoju, Otitoju and Oke (2020), CO^2 discharges are highly linked with the growth of the economy and the use of energy. Further to this the authors also emphasize the necessity for a worldwide evolution into an economy possessing low carbon emissions, mainly through green finance, which further allows driving considerable investment in clean energy to reduce CO^2 emissions significantly.

The progression of technology diffusion keeps a significant role in enforcing greener development (Jan, Durrani, & Khan, 2021). Aldieri et al. (2019) have found a strong linkage between environmental innovation and economic productivity, similarly, in the study of Wang et al. (2019), the importance has been given to the industrial policy regarding the use of mixed technologies and its effect on the innovation towards sustainability of wind power. This demonstrates that the procedure of technology mix, such as the implementation and utilize new energy resources which have a substantial impact on an economy (Jan *et al*., 2021).

For different countries, the prior literature provides contradictory findings on the linkage between energy consumption and economic growth in different periods (Azam, Rafiq, Shafique, Ateeq, & Yuan, 2020). Baig and Baig (2021) established a noteworthy extensive association concerning CO^2 emissions and economic factors likewise GDP, population, capital and energy utilization in Pakistan from the period of 1970 to 2010. Jan et al. (2021) have also confirmed a significant affiliation between different energy sources and fiscal progression in Pakistan from the period 1972 – 2015. Further to this, they added that renewable energy sources affect economic growth more efficiently than non-renewable energy sources. Halkos and Gkampoura(2021) have studied the linkage between CO^2 emissions, economic growth, renewable and non-renewable energy consumption in 119 countries between 2000 and 2018. According to their findings, CO^2 emissions drive economic growth in both directions for all income levels. On the other hand, Isik, Ongan and Özdemir (2019) studied the relationship between GDP, energy sources, population and release of carbon in the US, the findings indicate an inverse association among the non-conventional energy sources and carbon emissions.

Hanif (2018) conducted a separate study from 1995 to 2015 on the markets of Sub-Saharan Africa, the result postulates that nonrenewable energy sources have a favourable relation with CO^2 emissions, but renewables have a substantial negative link with CO^2 emissions. Bhat (2018) analyzed the relationship between population, capital, labour, Income and carbon discharges for the period of 1992 to 2016 in five emerging BRICS economies, the results show a strong linkage for all the variables towards CO^2.

Between 1980 and 2011, a study was undertaken in Senegal and Sierra Leone that showed a strong long term connection between economic development, modernization, power use, and CO^2 emissions (Asumadu-Sarkodie & Owusu, 2017a, 2017b). Destek (2017) specified that the nonrenewable energy source from biomass directly affects the growth of an economy positively. A study in China from the period of 1995 to 2014 by Fan and Lei (2017) evaluated the link between variables such as CO^2 emissions, gross domestic product, and transport. The study affirms that both transport and Pollutant emissions contribute to GDP growth. Işik et al. (2017) examined the connection between tourism, the monetary sector, and economic development in research for Greece. They discovered that the variable of tourism, in particular, boosts Greenhouse gasses.

Saboori et al. (2017) conducted a causal analysis for China, Japan, and South Korea from 1980 to 2013. They discovered that in China and Japan, oil consumption causes GDP, whereas, in South Korea, oil consumption causes pollution problems in the form of CO^2. According to Azam et al. (2016), during the period 1971–2013, energy consumption and CO^2 emissions have a detrimental and substantial connection with Output, whereas trade and workforce are positively related to the sustainable economy. Sulaiman and Abdul-Rahim (2017) tested the association between GDP, energy usage, and Carbon intensity in Malaysia between 1975 and 2015 and discovered that while Carbon intensity and energy usage had no considerable impact on the output, energy usage and Economic output had a substantial contribution to environmental deterioration.

Many authors argue that in developing countries there are many limitations in implementing renewable energy systems (Jan et al., 2021; Inglesi-Lotz & Dogan, 2018; Zoundi, 2017). Sinha and Shahbaz (2018) argue that the initial stages of installing renewable energy systems for low-income countries are much difficult, as it costs much higher due to the use and import of advanced technologies (Inglesi-Lotz & Dogan, 2018; Zoundi, 2017).

Methodology

Model Specification Data

The research examined the impact of energy utilization and economic progress on Pakistan's carbon emissions using yearly data from the World Development Indicators (WDI) from 1971 to 2017 (World Bank, 2020). Emissions of CO^2 were measured in metric tonnes, economic growth was measured in GDP per capita in constant local currency units, hydroelectricity form of energy was measured as power generation from hydroelectric sources (percentage of total) as a renewable source of energy, and conventional energy consumption was measured as fossil electricity generation (percentage of total). CO^2 emissions were calculated as metric tonnes per capita, economic growth was calculated as per capita GDP in constant LCU, hydroelectric energy production was calculated as (percentage of total energy) under the renewable source of energy, and conventional energy consumption was calculated as fossil fuel energy consumption (per cent of total energy).

Variables	Proxy	Source
1- Economic Growth	GDP per capita LCU	WDI World Bank
2- Emissions of CO^2	CO^2 in Metric Tonnes	
3- Population	The population of the country	
4- Energy (Electricity use)		
a- Renewable Electricity consumption	HYDEL Electricity percentage of total energy	
b- Non-renewable electricity consumption	NREC percentage of total energy	

All series have been transformed into logarithmic form to eliminate the problem of heteroscedasticity (Hundie, 2014). The autoregressive distributed lag (ARDL) method of estimation is used in this study to scrutinize the adjustment that is caused by the predictor variable in the response variable (Jordan & Philips, 2018).

Unit Root Testing

A unit root test is needed before dynamic ARDL modelling to check the presence of unit root in every variable and the order in which the respective variables are integrated. If there is no stationary variable, it might lead to biased regression. The study will check the unit root of data series in levels and first difference both. In case any variable is found stationary at levels, it will be I(0) variable and any stationarity at first difference will be called I(1) variable or it can be said that variable is integrated of order 1. Those variables which are stationary at levels or first difference can be used in the estimation of the ARDL approach. For that purpose unit root tests like Augmented Dickey-Fuller (Dickey and Fuller 1979) and Phillips-Peron (Phillips and Perron 1988) were used to inspect the stochastic tendency in the series.

On the contrary, Baum (2001) argues that an acknowledged flaw of the traditional unit root tests with a null hypothesis as I(1) is considered a sign of the presence of unit root. This is because these conventional tests probably do misperception of structural breaks in the series and in the presence of structural breaks these might fail to reject the unit root hypothesis. Shahbaz et al. (2013) further contended that these tests yield misleading and falsified results as there is no knowledge on the structural breaks in the series. To counter such issues structural break test proposed by Zivot and Andrews (1992) was employed as well.
The main regression equation of the study is

$$CO^2 = \beta_0 + \beta_1 GDP + \beta_2 POP + \beta_3 NREC + \beta_4 HYDEL + ut \qquad (1)$$

After taking logs of certain variables like GDP and population the equation becomes

$$CO^2 = \beta_0 + \beta_1 LGDP + \beta_2 LPOP + \beta_3 NREC + \beta_4 HYDEL + ut \qquad (2)$$

Where β0 represents the slope, β1 to β4 are the coefficient estimates of independent variables and ut represents the error term.

Lag Length Selection

Bahmani-Oskooee and Harvey (2006) argued that the F-stat value in ARDL Bound test is very subtle to the lag length criteria, therefore before ARDL estimation the proper lag length criteria is examined.

ARDL Estimation

As per the previous studies by Hundie (2018), Khan, Teng, Khan, Khan (2019a, b) and Qazi, Alam, Ahmad and Ambreen (2021) the study utilized the ARDL Bound testing approach by Pesaran and Pesaran (1997); Pesaran et al. (2000) and Pesaran et al. (2001). When the series is integrated at levels or first difference and small in size, it is beneficial to use the ARDL bounds test. According to Pesaran et al. (2000), even in the case of any endogeneity issue in the series, this test is very effective in yielding fair long-run values as well the t-stat values. The F-stat value will be assessed with maximum and minimum critical limits to decide the existence of cointegration among variables in the ARDL estimation. According to Pesaran et al. (2001), cointegration will exist in case the F-stat value is more than the upper bound, no cointegration if the value is less than the lower bound and inconclusive if the values are between the upper and lower bounds. Moreover, the error correction model ECM under ARDL is also estimated. In this context, the integrating measure is known as the error term (ECT). It tells about any deviance from the long-run equilibrium. This deviancy is then slowly corrected through short-term adjustments. The error term should be significantly negative. The statistic represents the rate of transition towards long-run stability. The ECM model is shown in equation-8. Following are possible ARDL Bound estimation equations from eq-3 to eq-7.

$$\Delta CO2 = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta CO2_{t-i} \sum_{a=0}^{n} \alpha_a \Delta LGDP_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LPOP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta NREC_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta HYDEL_{t-d} + \gamma_1 CO2_{t-1} + \gamma_2 LGDP_{t-1} + \gamma_3 LPOP_{t-1} + \gamma_4 NREC_{t-1} + \gamma_5 HYDEL_{t-1} + \varepsilon_{1t} \tag{3}$$

$$\Delta LGDP = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta LGDP_{t-i} \sum_{a=0}^{n} \alpha_a \Delta CO2_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LPOP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta NREC_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta HYDEL_{t-d} + \gamma_1 LGDP_{t-1} + \gamma_2 CO2_{t-1} + \gamma_3 LPOP_{t-1} + \gamma_4 NREC_{t-1} + \gamma_5 HYDEL_{t-1} + \varepsilon_{1t} \tag{4}$$

$$\Delta LPOP = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta LPOP_{t-i} \sum_{a=0}^{n} \alpha_a \Delta CO2_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LGDP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta NREC_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta HYDEL_{t-d} + \gamma_1 LPOP_{t-1} + \gamma_2 CO2_{t-1} + \gamma_3 LGDP_{t-1} + \gamma_4 NREC_{t-1} + \gamma_5 HYDEL_{t-1} + \varepsilon_{1t} \tag{5}$$

$$\Delta NREC = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta NREC_{t-i} \sum_{a=0}^{n} \alpha_a \Delta CO2_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LGDP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta LPOP_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta HYDEL_{t-d} + \gamma_1 NREC_{t-1} + \gamma_2 CO2_{t-1} + \gamma_3 LGDP_{t-1} + \gamma_4 LPOP_{t-1} + \gamma_5 HYDEL_{t-1} + \varepsilon_{1t} \tag{6}$$

$$\Delta HYDEL = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta HYDEL_{t-i} \sum_{a=0}^{n} \alpha_a \Delta CO2_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LGDP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta LPOP_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta NREC_{t-d} + \gamma_1 HYDEL_{t-1} + \gamma_2 CO2_{t-1} + \gamma_3 LGDP_{t-1} + \gamma_4 LPOP_{t-1} + \gamma_5 NREC_{t-1} + \varepsilon_{1t} \tag{7}$$

Following equation 8 is the error correction model for the concerned short-run association:

$$\Delta CO2 = \alpha_1 + \sum_{i=1}^{n} \alpha_i \Delta CO2_{t-i} \sum_{a=0}^{n} \alpha_a \Delta LGDP_{t-a} + \sum_{b=0}^{n} \alpha_b \Delta LPOP_{t-b} + \sum_{c=0}^{n} \alpha_c \Delta NREC_{t-c} + \sum_{d=0}^{n} \alpha_d \Delta HYDEL_{t-d} + \lambda ECT_{t-1} + \varepsilon_{1t} \tag{8}$$

Granger Causality

This study will employ MWALD granger causality under the augmented VAR model. MWALD is a modified Wald test, known to be the Toda Yamamoto Granger causality test (Toda Yamamoto, 1995). As per Dolado and Lut¨kepohl (1996) in this procedure order of maximum integration is prespecified and is denoted by $d_{\max.}$ Under VAR specification an optimum order-level *K* is considered to be the best as 1, i.e. $d_{\max}$=1. The concerned augmented VAR $k+d_{max}$ model estimated by TY granger causality is shown in equation 9 as follows.

$$CO2_t = \alpha_0 + \sum_{i=1}^{k} \beta_{1i} CO2_{t-i} + \sum_{j=k+1}^{dmax} \beta_{2j} CO2_{t-j} + \sum_{i=1}^{K} \beta_{3i} LGDP_{t-i} + \sum_{j=k+1}^{dmax} \beta_{4j} LGDP_{t-j} + \sum_{i=1}^{k} \beta_{5i} LPOP_{t-i} + \sum_{j=k+1}^{dmax} \beta_{6j} LPOP_{t-j} + \sum_{i=1}^{k} \beta_{7i} NREC_{t-i} + \sum_{j=k+1}^{dmax} \beta_{8j} NREC_{t-j} + \sum_{i=1}^{k} \beta_{9i} HYDEL_{t-i} + \sum_{j=k+1}^{dmax} \beta_{10j} HYDEL_{t-j} + \varepsilon_{1t} \tag{9}$$

$$LGDP_t = \alpha_0 + \sum_{i=1}^{k}\beta_{1i}LGDP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{2j}LGDP_{t-j} + \sum_{i=1}^{K}\beta_{3i}CO2_{t-i} + \sum_{j=k+1}^{dmax}\beta_{4j}CO2_{t-j} + \sum_{i=1}^{k}\beta_{5i}LPOP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{6j}LPOP_{t-j} + \sum_{i=1}^{k}\beta_{7i}NREC_{t-i} + \sum_{j=k+1}^{dmax}\beta_{8j}NREC_{t-j} + \sum_{i=1}^{k}\beta_{9i}HYDEL_{t-i} + \sum_{j=k+1}^{dmax}\beta_{10j}HYDEL_{t-j} + \varepsilon_{1t} \qquad (10)$$

$$LPOP_t = \alpha_0 + \sum_{i=1}^{k}\beta_{1i}LPOP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{2j}LPOP_{t-j} + \sum_{i=1}^{K}\beta_{3i}CO2_{t-i} + \sum_{j=k+1}^{dmax}\beta_{4j}CO2_{t-j} + \sum_{i=1}^{k}\beta_{5i}LGDP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{6j}LGDP_{t-j} + \sum_{i=1}^{k}\beta_{7i}NREC_{t-i} + \sum_{j=k+1}^{dmax}\beta_{8j}NREC_{t-j} + \sum_{i=1}^{k}\beta_{9i}HYDEL_{t-i} + \sum_{j=k+1}^{dmax}\beta_{10j}HYDEL_{t-j} + \varepsilon_{1t} \qquad (11)$$

$$NREC_t = \alpha_0 + \sum_{i=1}^{k}\beta_{1i}NREC_{t-i} + \sum_{j=k+1}^{dmax}\beta_{2j}NREC_{t-j} + \sum_{i=1}^{K}\beta_{3i}CO2_{t-i} + \sum_{j=k+1}^{dmax}\beta_{4j}CO2_{t-j} + \sum_{i=1}^{k}\beta_{5i}LGDP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{6j}LGDP_{t-j} + \sum_{i=1}^{k}\beta_{7i}LPOP_{t-i} + \sum_{j=k+1}^{dmax}\beta_{8j}LPOP + \sum_{i=1}^{k}\beta_{9i}HYDEL_{t-i} + \sum_{j=k+1}^{dmax}\beta_{10j}HYDEL_{t-j} + \varepsilon_{1t} \qquad (12$$

Results and Discussion

Conventional unit root analysis is shown in table 1. The method used is the augmented dickey fuller ADF test. Results revealed that all the concerned variables have unit root at levels, but become stationary at 1st difference at 5% or less significance level. Unit root test with structural breaks is given in table 2. Its result revealed that all the variables are stationary at 1st difference except the CO^2 variable which is stationary at levels.

Table 1. *Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) Test*

ADF

	At Level					
		CO2	LGDP	LPOP	NREC	HYDEL
With Constant	t-Statistic	0.5696	-1.6292	-3.5444	-1.9723	-0.9489
	Prob.	***0.9874***	***0.4599***	***0.0113***	***0.2976***	***0.7636***
		n0	n0	**	n0	n0
With Constant & Trend	t-Statistic	-3.0913	-1.7099	-2.8658	1.6037	-2.4606
	Prob.	***0.1202***	***0.7308***	***0.1842***	***1.0000***	***0.3453***
		n0	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	3.4582	4.2593	0.3275	0.3360	-1.0236
	Prob.	***0.9998***	***1.0000***	***0.7756***	***0.7782***	***0.2711***
		n0	n0	n0	n0	n0
	At First Difference					
		d(CO2)	d(LGDP)	d(LPOP)	d(NREC)	d(HYDEL)
With Constant	t-Statistic	-7.0751	-5.7865	-0.6433	-3.2208	-9.1586
	Prob.	***0.0000***	***0.0000***	***0.8499***	***0.0251***	***0.0000***
		***	***	n0	**	***
With Constant & Trend	t-Statistic	-4.7627	-5.8982	-3.4293	-3.1772	-9.0824
	Prob.	***0.0023***	***0.0001***	***0.0607***	***0.1025***	***0.0000***
		***	***	*	n0	***
Without Constant & Trend	t-Statistic	-2.7305	-3.2191	-1.4157	-3.2068	-9.0765
	Prob.	***0.0074***	***0.0019***	***0.1439***	***0.0019***	***0.0000***
		***	***	n0	***	***

pp

	At Level					
		CO^2	LGDP	LPOP	NREC	HYDEL
With Constant	t-Statistic	0.4558	-0.9304	-5.0742	-1.9090	-0.7618
	Prob.	***0.9833***	***0.7698***	***0.0001***	***0.3255***	***0.8205***
		n0	n0	***	n0	n0
With Constant & Trend	t-Statistic	-3.4375	-1.6116	1.3333	2.5566	-2.3932
	Prob.	***0.0586***	***0.7733***	***1.0000***	***1.0000***	***0.3782***
		*	n0	n0	n0	n0
Without Constant & Trend	t-Statistic	3.1562	6.0642	16.6092	1.0760	-1.1532
	Prob.	***0.9994***	***1.0000***	***1.0000***	***0.9242***	***0.2233***
		n0	n0	n0	n0	n0

	At First Difference					
		d(CO^2)	d(LGDP)	d(LPOP)	d(NREC)	d(HYDEL)
With Constant	t-Statistic	-7.0294	-5.8092	-0.1987	-3.2447	-9.1716
	Prob.	***0.0000***	***0.0000***	***0.9312***	***0.0236***	***0.0000***
		***	***	n0	**	***
With Constant & Trend	t-Statistic	-6.9261	-5.8982	-3.0026	-3.4449	-9.0972
	Prob.	***0.0000***	***0.0001***	***0.1426***	***0.0579***	***0.0000***
		***	***	n0	*	***
Without Constant & Trend	t-Statistic	-5.6119	-3.1865	-0.9005	-3.2909	-8.9611
	Prob.	***0.0000***	***0.0021***	***0.3208***	***0.0015***	***0.0000***
		***	***	n0	***	***

Notes: (*), (**), and (***) shows the level of significance at 10%, 5%; (***), and 1% respectively. (no) signifies Not Significant

Table 2. *Zivot Andrews Unit Root Test*

	Statistics (Level)			**Statistics (first difference)**			**Conclusion**
variables	ZAI	ZAT	ZAB	ZAI	ZAT	ZAB	
CO^2							
Time Break	2007***	1996***	1992***	-	-	-	*I*(0)
Lag length	4	4	4				
LGDP							
Time Break	1979	1992	1979	1977***	2007***	1992***	*I*(1)
Lag length	0	7	0	0	0	0	
LPOP							
Time Break	1991**	1987	1991	1998	1976*	1997**	*I*(1)
Lag length	8	8	8	8	0	6	
NREC							
Time Break	2017	2005	2000	2016*	2017**	2013***	*I*(1)
Lag length	0	3	1	4	4	0	
HYDEL							

Time Break	1995	2000	2002***	1980***	1999***	1992***	*I*(1)
Lag length	8	8	6	0	0	0	

Before estimation of equation 3, identifying the optimal lag order is needed. The estimation of the VAR model identifies the optimum lag as 5 as per AIC and SIC shown in table 3.

Table 3. *VAR Lag Order Selection Criteria*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-49.94959	NA	8.86e-06	2.555795	2.760586	2.631315
1	297.1492	597.3328	2.79e-12	-12.42554	-11.19680	-11.97242
2	369.5760	107.7981	3.22e-13	-14.63144	-12.37874	-13.80072
3	451.9499	103.4463	2.55e-14	-17.30000	-14.02334	-16.09167
4	522.0958	71.77719	4.08e-15	-19.39980	-15.09920	-17.81387
5	572.6798	**39.99668***	**2.05e-15***	**-20.58976***	**-15.26520***	**-18.62623***

* specifies lag order designated by different criteria.

Table 4 shows the critical F- Bounds value i.e. 6.53. This F- stat is larger than the upper bound at 1% significance level, rejecting the null hypothesis of no cointegration for the concerned equation of CO^2 as the dependent variable.

Table 4. *F-Bounds Test*
FCO^2 (CO^2| LGDP, LPOP, NREC, HYDEL)

Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	**6.526385**	10%	2.45	3.52
K	5	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06
Actual Sample Size	44		Finite Sample: n=45	
		10%	2.638	3.772
		5%	3.178	4.45
		1%	4.394	5.914
			Finite Sample: n=40	
		10%	2.66	3.838
		5%	3.202	4.544
		1%	4.428	6.25

After the study identifies the presence of cointegration for the concerned equation 3, table 5 indicates the long-run and short-run estimation following the lag specification (5, 0, 1, 0, 0). It was revealed that the coefficient of GDP is 0.311 and significant at 5%. When GDP grows by one unit, the CO^2 level rises by 0.311 units. With a population coefficient of 0.205, an increase in the population increases emissions by 0.205 units. This is significant at 5 per cent. A one-unit increase in the NREC raises emission levels by 0.0009 units, making the NREC coefficient 0.0009 and very insignificant. Finally, HYDEL's energy consumption coefficient is -0.0016, making it highly significant at a 1 per cent level of significance. It demonstrates that increasing HYDEL energy usage by one unit results in a 0.0016-unit reduction in emissions. The HYDEL source has a negative sign, although the difference between the positive and negative values is negligible. To a great extent, this research confirms what has already been found in other studies of Khan, Khan and Akhtar (2020), Ancer (2019), Dogan and Seker (2016), Jebli et al. (2016), Ali et al. (2015). It has been shown from past studies that the use of natural resources of non-renewable energy increases harmful emissions and contributes to CO^2 emissions, thus reducing environmental quality. Most non-renewable energy resources are used in developing economies for an economic process that results in the dilapidation of the environment. In reality, this requires that governments take broad initiatives to consolidate their energy resources to meet growing demand in the future and encourage such investments that can provide sustainable green technologies. Developing countries also trigger the destruction of the environment, since they are employing in industrial and other commercial development the non-renewable energy resources that boost social CO^2 emissions.

According to the short-term outcomes, the emission levels are being caused by CO^2 lags from the past. Likewise, the population has a short-term impact on emission levels, moving them in the other way. As stated by the error correction term ECT (-0.781), a shock-induced deviation in long-term CO^2 emissions will be corrected by 78.1 per cent over the next year. It will take roughly 1.4 years to complete the entire correction process. Adjusted R^2 shows that 99% of independent variables are explaining the changes in CO^2 emissions. DW value is 2.28, which is near to 2 and can be confirmed that there is no issue of autocorrelation in the residuals. The p-value of the F-stat is significant which means that the independent variables are used to improve the model fit.

Table 5. *ARDL Long Run and Short Form*

Dependent Variable: CO^2

Selected Model: ARDL(5, 0, 1, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Long-run estimates				
LGDP	0.311152	0.136376	2.281578	0.0298
LPOP	0.205106	0.097962	2.093719	0.0448
NREC	0.000903	0.001313	0.687858	0.4968
HYDEL	-0.001618	0.000584	-2.770793	0.0095
Short-run estimates				
C	-4.144917	0.690577	-6.002104	0.0000
D(CO^2(-1))	0.282398	0.126281	2.236268	0.0324
D(CO^2(-2))	0.512739	0.131659	3.894433	0.0005
D(CO^2(-3))	0.267277	0.118083	2.263479	0.0305
D(LPOP)	4.180514	1.192465	3.505776	0.0014
D1992	-0.030225	0.021338	-1.416511	0.1663
D2007S	0.003839	0.010472	0.366571	0.7164
CointEq(-1)*	-0.781256	0.128942	-6.058953	0.0000

R-squared	0.994118
Adjusted R-squared	0.991765
Durbin-Watson stat	2.280928
F-statistic	422.5166
Prob(F-statistic)	0.000000

Diagnostics tests are shown in table 6, which validated the soundness of the model. There is found no heteroscedasticity and serial correlation issues. Residuals are normally distributed and there is no issue of non-linearity in the model. CUSUM and CUSUM of square are shown in figure 1. As the residuals are within the critical bound of 5%, therefore no issue of stability is found in the model.

Table 6. *Residual and Stability Diagnostics*

Heteroskedasticity Test: Breusch-Pagan-Godfrey		
F-statistics	0.833	Prob. F(11,32)
Obs*R-squared	9.796	Prob. Chi-Square(11)
Breusch-Godfrey Serial Correlation LM Test		
F-statistics	2.154	Prob. F(2,30)
Obs*R-squared	5.526	Prob. Chi-Square(2)
Histogram-Normality: Jarque-Bera Statistic		
Jarque-Bera	1.313	P-value
Ramsay RESET Test		

	Value	Df
t-statistics	1.466	27
F-statistics	2.150	(1,27)

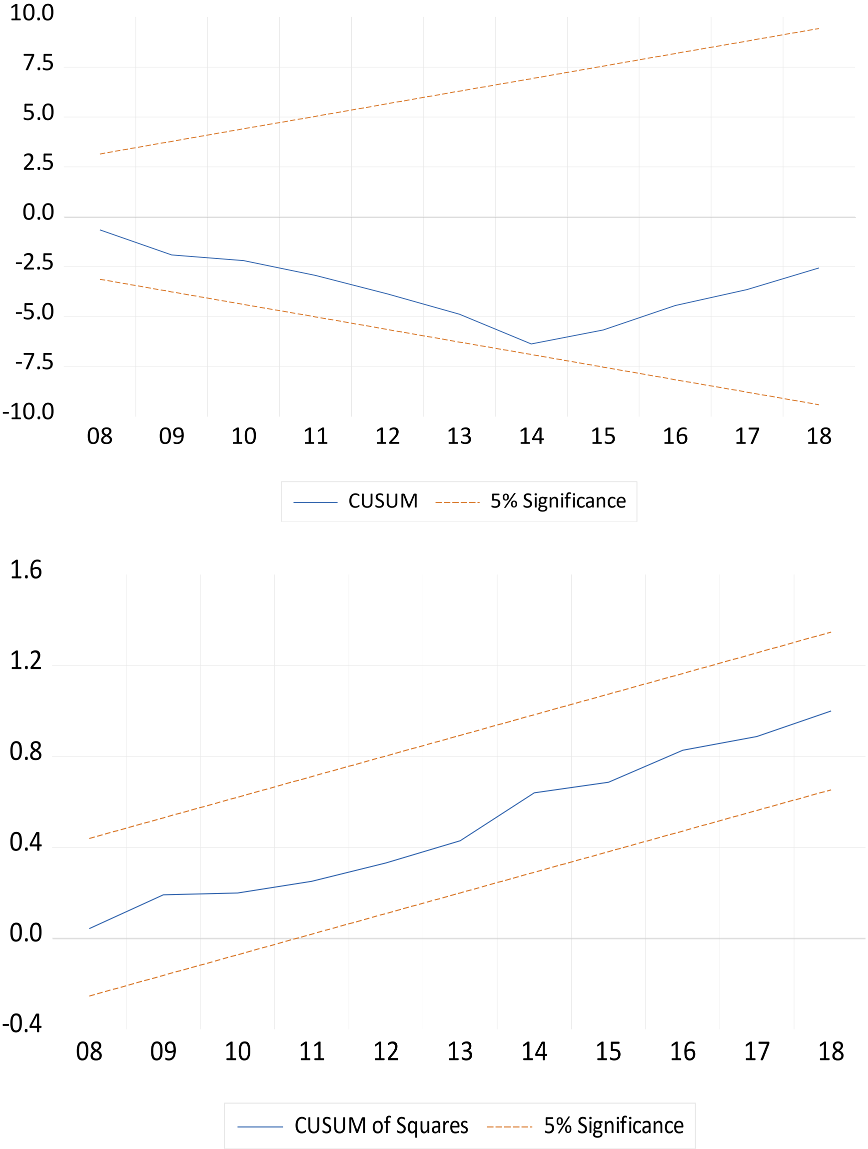

Figure1. *Plot of cumulative sum and cumulative sum of squares*

Table 7 shows the long-run causality between the variables. There is a bi-directional Granger causality between CO^2 and GDP. It means that economic growth in Pakistan is causing CO^2 emissions and vice versa. Non-renewable energy consumption has a bi-directional causality towards CO^2 stating fossil fuel is causing emissions of CO^2 and vice versa. The population has a unidirectional causality towards CO^2. The population and GDP are linked in a causal way that goes both ways. Between Hydel and GDP, there is a bidirectional causality, while from NREC to GDP, there is a unidirectional causality. It states that the more the investment in the Hydel electricity sector, the more will be the economic growth and vice versa. Similarly, fossil fuel generations are helping the economy to grow, but no causality was found from LGDP to NREC, meaning growth in the economy does not cause fossil fuel generations. The results are in line with the study of Azam, Rafiq, Shafique and Yuan (2021); Sarker, Wang, and Adnan (2019) but different from the study of Cevik, Yaldirim, and Dibooglu (2020), as they failed to validate any causation between Hydel electricity and GDP.

Table 7. *Long-run Granger Causality/ MWALD/ Toda Yamamoto Approach*

Dep. Variable	**CO^2**	**LGDP**	**LPOP**	**NREC**	**HYDEL**	**Direction of Causality**
CO^2	**-**	**14.485***	**0.508*****	**11.811***	4.691	LGDP→CO^2, LPOP→CO^2, NREC→CO^2
LGDP	**6.046*****	-	**19.198***	**21.211***	**32.297***	CO^2→LGDP, LPOP→LGDP, NREC→LGDP, HYDEL→LGDP
LPOP	3.513	**6.512*****	-	5.282	0.734	LGDP→LPOP
NREC	**16.894***	2.138	5.616	-	2.209	CO^2→NREC
HYDEL	1.106	**14.428***	4.469	5.630	-	LGDP→HYDEL

Note: The asterisks *, ** and *** over the Chi-square values denotes significance level at 1, 5 and 10 per cent respectively.

Conclusion

As the title implies, the article's primary objective is to examine the link between economic growth, electricity consumption, and carbon dioxide emissions in Pakistan from 1971 to 2018. The Unit roots test was used to determine the stationarity of variables. At the levels, all variables were assumed to be non-stationary but became stationary at the first difference. To increase robustness, the Zivot-Andrews structural break test was used, which confirmed that all variables are stationary at the first difference, but only the carbon emission variable is stationary at levels. The existence of cointegration was checked through the ARDL Bounds test. The F-statistic of Bounds test confirmed the existence of cointegration among the concerned variables. Further, the long-run ARDL results confirmed a positive relationship between CO^2 emissions, and the independent variables of GDP, population and energy consumption from Hydel sources. CO2 emissions and non-renewable energy usage were found to be negatively related. In the short-run ARDL results the previous lags of CO^2 and population were regressing the CO^2 emissions.

Apart from cointegration, the study performed a long-run causality test called the Toda Yamamoto Granger causality test. It revealed a bi-directional causality for GDP and non-renewable energy consumption with the CO^2 emissions and uni-directional causality for the population with CO^2 emissions. There was neutrality causality between CO^2 emissions and HYDEL source of energy consumption. Furthermore, HYDEL energy consumption and non-renewable energy consumption had bidirectional and uni-directional causality with GDP respectively.

Recommendations

Environmental deterioration harms social life, causing immense situations such as excessive rainfall, extreme weather conditions, and severe floods to occur more frequently over time. After 17 years, the National Assembly's Environmental Protection Act of 1997 was updated to an Environmental Protection Ordinance, which still has some flaws. The study is expected to aid in the development of policies that can be incorporated into the preexisting policy statement. The causal relationship between CO2 emissions, NREC, HYDEL consumption, and economic growth will aid in the declaration of inclusive policies for economic growth based on the use of environmentally friendly technology that will minimize the destruction of the environment.

Many policy suggestions can be drawn from the study. As there is a causal relationship between overall energy consumption and the GDP of Pakistan, it emphasizes that attaining higher economic growth, in the long run, will need an ensuring supply of energy. The government of Pakistan needs to work to strengthen support to ensure enough energy supplies in the economy because Pakistan has been experiencing severe electricity shortages. As the study has found causality between energy and GDP, therefore in case of energy shortages keeps direct implications for economic growth.

As the supply of energy is increased, ultimately population in reach will consume more of it, and it results in CO^2 emissions. As a result, it suggests that while energy resources are required for further economic expansion, they will cause pollution. The authorities should consider decisive action to enhance renewable energy's proportion in the energy portfolio. Exploration of various renewable energy options is worthwhile as a policy implication for lowering carbon footprint. Hydel, Biomass and solar energy are examples of renewable resources. The abundance of biomass in Pakistan can be used to generate electricity, heat, and cooling purpose.

As the use of solar resources will reduce pollution and quality of air, the Pakistani government should continue to fund renewable energy systems such as photovoltaic panels and promote households to install them to minimize electricity consumption and thus cut emissions. To reduce emissions from non-renewable sources, the Government of Pakistan should encourage a transition away from the usual usage of natural gas, and imported fuel from the Gulf, and toward investment in clean energy technologies that are affordable to domestic consumers. The government of Pakistan should engage the local population to encourage them toward plantation to enhance the proportion of forest in Pakistan to combat climate change therein. The consumption of these renewable energies is expected to reduce the amount of fossil-fuel-based electricity generation, lowering Pakistan's carbon emissions rate.

CO^2 and economic growth have a bidirectional causality or feedback effect. It means that country is achieving economic growth at the expense of a pollution-free environment, which challenges the eminence of economic growth. To address this issue, it is suggested that emission reduction operations be prioritized in Pakistan's energy and climate change legislation to limit CO2 emissions-related losses. To efficiently manage the feedback effect the government should induce pollution mitigation activities in energy as well environmental policies. Policymakers should develop regulations that promote the use of eco-friendly technology, machinery, transportation and facilities to reduce CO^2 in the long run.

References

Acar, S., & Lindmark, M. (2017). Convergence of CO2 emissions and economic growth in the OECD countries: Did the type of fuel matter? *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(7), 618–627. https://doi.org/10.1080/15567249.2016.1249807

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy*, *96*, 131–143. https://doi.org/10.1016/j.enpol.2016.05.032

Aldieri, L., Kotsemir, M., & Paolo Vinci, C. (2019). Environmental innovations and productivity: Empirical evidence from Russian regions. *Resources Policy*, 101444. https://doi.org/10.1016/j.resourpol.2019.101444

Ali A, Khatoon S, Ather M, Akhtar N (2015) Modeling energy consumption, carbon emission and economic growth: Empirical analysis for Pakistan. International Journal of Energy Economics and Policy, 5(2), 624–630

Alshehry, A. S., & Belloumi, M. (2015). Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *41*, 237–247. https://doi.org/10.1016/j.rser.2014.08.004

Amjad Chaudhry, A. (2010). A Panel Data Analysis of Electricity Demand in Pakistan. *THE LAHORE JOURNAL OF ECONOMICS*, *15*(Special Edition), 75–106. https://doi.org/10.35536/lje.2010.v15.isp.a5

Anadolu Agency. (2021, June 4). Pakistan’s fight to reverse climate change gains recognition. Retrieved December 20, 2021, from https://www.aa.com.tr/en/asia-pacific/pakistan-s-fight-to-reverse-climate-change-gains-recognition/2263517

Ang, J. B. (2007). CO2 emissions, energy consumption, and output in France. *Energy Policy*, *35*(10), 4772–4778. https://doi.org/10.1016/j.enpol.2007.03.032

Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics*, *69*(11), 2255–2260. https://doi.org/10.1016/j.ecolecon.2010.06.014

Arouri, M. E. H., ben Youssef, A., M'henni, H., & Rault, C. (2012). Energy consumption, economic growth and CO2 emissions in Middle East and North African countries. *Energy Policy*, *45*, 342–349. https://doi.org/10.1016/j.enpol.2012.02.042

Asumadu-Sarkodie, S., & Owusu, P. A. (2017a). A multivariate analysis of carbon dioxide emissions, electricity consumption, economic growth, financial development, industrialization, and urbanization in Senegal. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(1), 77–84. https://doi.org/10.1080/15567249.2016.1227886

Asumadu-Sarkodie, S., & Owusu, P. A. (2017b). The causal effect of carbon dioxide emissions, electricity consumption, economic growth, and industrialization in Sierra Leone. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(1), 32–39. https://doi.org/10.1080/15567249.2016.1225135

Azam, A., Rafiq, M., Shafique, M., Ateeq, M., & Yuan, J. (2020). Causality Relationship Between Electricity Supply and Economic Growth: Evidence from Pakistan. *Energies*, *13*(4), 837. https://doi.org/10.3390/en13040837

Azam, M., Khan, A. Q., Abdullah, H. B., & Qureshi, M. E. (2015). The impact of CO2 emissions on economic growth: evidence from selected higher CO2 emissions economies. *Environmental Science and Pollution Research*, *23*(7), 6376–6389. https://doi.org/10.1007/s11356-015-5817-4

Baig, M. A., & Baig, M. A. (2021). Impact of CO $_2$ Emissions: Evidence from Pakistan. *SSRN Electronic Journal*. Published. https://doi.org/10.2139/ssrn.2472838

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to CO2 emissions? *Energy Policy*, *113*, 356–367. https://doi.org/10.1016/j.enpol.2017.10.050

Bhat, J. A. (2018). Renewable and non-renewable energy consumption—impact on economic growth and CO2 emissions in five emerging market economies. *Environmental Science and Pollution Research*, *25*(35), 35515–35530. https://doi.org/10.1007/s11356-018-3523-8

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for Testing the Constancy of Regression Relationships Over Time. *Journal of the Royal Statistical Society: Series B (Methodological)*, *37*(2), 149–163. https://doi.org/10.1111/j.2517-6161.1975.tb01532.x

Destek, M. A. (2017). Biomass energy consumption and economic growth: Evidence from top 10 biomass consumer countries. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(10), 853–858. https://doi.org/10.1080/15567249.2017.1314393

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, *74*(366a), 427–431. https://doi.org/10.1080/01621459.1979.10482531

Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews*, *60*, 1074–1085. https://doi.org/10.1016/j.rser.2016.02.006

Fan, F., & Lei, Y. (2017). Responsive relationship between energy-related carbon dioxide emissions from the transportation sector and economic growth in Beijing—Based on decoupling theory. *International Journal of Sustainable Transportation*, *11*(10), 764–775. https://doi.org/10.1080/15568318.2017.1317887

Halkos, G. E., & Gkampoura, E. C. (2021). Examining the Linkages among Carbon Dioxide Emissions, Electricity Production and Economic Growth in Different Income Levels. *Energies*, *14*(6), 1682. https://doi.org/10.3390/en14061682

Hanif, I. (2018). Impact of economic growth, nonrenewable and renewable energy consumption, and urbanization on carbon emissions in Sub-Saharan Africa. *Environmental Science and Pollution Research*, *25*(15), 15057–15067. https://doi.org/10.1007/s11356-018-1753-4

Hayat, K., Nadeem, A., & Jan, S. (2019). The impact of green marketing mix on green buying behavior: (a case of Khyber Pakhtunkhwa evidence from the customers). City University Research Journal, 09(01), 27–40.

Inglesi-Lotz, R., & Dogan, E. (2018). The role of renewable versus non-renewable energy to the level of CO2 emissions a panel analysis of sub- Saharan Africa's Big 10 electricity generators. *Renewable Energy*, *123*, 36–43. https://doi.org/10.1016/j.renene.2018.02.041

Işik, C., Kasımatı, E., & Ongan, S. (2017). Analyzing the causalities between economic growth, financial development, international trade, tourism expenditure and/on the CO2emissions in Greece. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(7), 665–673. https://doi.org/10.1080/15567249.2016.1263251

Isik, C., Ongan, S., & ÖZdemir, D. (2019). The economic growth/development and environmental degradation: evidence from the US state-level EKC hypothesis. *Environmental Science and Pollution Research*, *26*(30), 30772–30781. https://doi.org/10.1007/s11356-019-06276-7

Işık, C., Ongan, S., & ÖZdemir, D. (2019). Testing the EKC hypothesis for ten US states: an application of heterogeneous panel estimation method. *Environmental Science and Pollution Research*, *26*(11), 10846–10853. https://doi.org/10.1007/s11356-019-04514-6

Jan, I., Durrani, S. F., & Khan, H. (2021). Does renewable energy efficiently spur economic growth? Evidence from Pakistan. *Environment, Development and Sustainability*, *23*(1), 373–387. https://doi.org/10.1007/s10668-019-00584-1

Jebli M.B, Youssef S.B, Ozturk I (2016) Testing environmental Kuznets curve hypothesis: The role of renewable and nonrenewable energy consumption and trade in OECD countries. Ecological Indicators, 60, 824–831. https://doi.org/10.1016/j.ecolind.2015.08.031

Jebli MB, Youssef SB (2015a) Economic growth, combustible renewables, and waste consumption, and CO2 emissions in North Africa. Environ Sci Pollut Res 22(20):16022–16030. https://doi.org/10.1007/s11356-015-4792-0

Jebli MB, Youssef SB (2015b) The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. Renew SustEnerg Rev 47:173–185. https://doi.org/10.1016/j.rser.2015.02.049

Kasman, A., & Duman, Y. S. (2015). CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: A panel data analysis. *Economic Modelling*, *44*, 97–103. https://doi.org/10.1016/j.econmod.2014.10.022

Khan, M. (2021). Effect of Natural Resources on Economic Growth in Pakistan: A Time Series Analysis. *Asian Journal of Economic Modelling*, *9*(1), 29–47. https://doi.org/10.18488/journal.8.2021.91.29.47

Khan, M. K., Khan, M. I., & Rehan, M. (2020). The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financial Innovation*, *6*(1). https://doi.org/10.1186/s40854-019-0162-0

Khan, M. K., Teng, J. Z., Khan, M. I., & Khan, M. O. (2019a). Impact of globalization, economic factors and energy consumption on CO2 emissions in Pakistan. *Science of The Total Environment*, *688*, 424–436. https://doi.org/10.1016/j.scitotenv.2019.06.065

Khan, M. K., Teng, J. Z., & Khan, M. I. (2019b). Effect of energy consumption and economic growth on carbon dioxide emissions in Pakistan with dynamic ARDL simulations approach. *Environmental Science and Pollution Research*, *26*(23), 23480–23490. https://doi.org/10.1007/s11356-019-05640-x

Khan, M. K., Teng, J. Z., Parvaiz, J., & Chaudhary, S. K. (2017). Nexuses between Economic Factors and Stock Returns in China. *International Journal of Economics and Finance*, *9*(9), 182. https://doi.org/10.5539/ijef.v9n9p182

Menyah, K., & Wolde-Rufael, Y. (2010). Energy consumption, pollutant emissions and economic growth in South Africa. *Energy Economics*, *32*(6), 1374–1382. https://doi.org/10.1016/j.eneco.2010.08.002

Narayan, P. K. (2005). The saving and investment nexus for China: evidence from cointegration tests. *Applied Economics*, *37*(17), 1979–1990. https://doi.org/10.1080/00036840500278103

Osobajo, O. A., Otitoju, A., Otitoju, M. A., & Oke, A. (2020). The Impact of Energy Consumption and Economic Growth on Carbon Dioxide Emissions. *Sustainability*, *12*(19), 7965. https://doi.org/10.3390/su12197965

Pao, H. T., & Tsai, C. M. (2010). CO2 emissions, energy consumption and economic growth in BRIC countries. *Energy Policy*, *38*(12), 7850–7860. https://doi.org/10.1016/j.enpol.2010.08.045

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616

PHILLIPS, P. C. B., & PERRON, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Qazi, U., Alam, A., Ahmad, S., & Ambreen, R. (2021). Impact of FDI and Electricity on the

Economic Growth of Pakistan: A Long Run Cointegration and Causality Analysis. *Research in World Economy*, *12*(2), 273. https://doi.org/10.5430/rwe.v12n2p273

Saboori, B., Rasoulinezhad, E., & Sung, J. (2017). The nexus of oil consumption, CO2 emissions and economic growth in China, Japan and South Korea. *Environmental Science and Pollution Research*, *24*(8), 7436–7455. https://doi.org/10.1007/s11356-017-8428-4

Shahbaz, M., Salah Uddin, G., Ur Rehman, I., & Imran, K. (2014). Industrialization, electricity consumption and CO2 emissions in Bangladesh. *Renewable and Sustainable Energy Reviews*, *31*, 575–586. https://doi.org/10.1016/j.rser.2013.12.028

Shahbaz, M., Solarin, S. A., Mahmood, H., & Arouri, M. (2013). Does financial development reduce CO2 emissions in Malaysian economy? A time series analysis. *Economic Modelling*, *35*, 145–152. https://doi.org/10.1016/j.econmod.2013.06.037

Siddiqui, R. (2004). Energy and Economic Growth in Pakistan. *The Pakistan Development Review*, *43*(2), 175–200. https://doi.org/10.30541/v43i2pp.175-200

Sinha, A., & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. *Renewable Energy*, *119*, 703–711. https://doi.org/10.1016/j.renene.2017.12.058

Sulaiman, C., & Abdul-Rahim, A. S. (2017). The relationship between CO2 emission, energy consumption and economic growth in Malaysia: a three-way linkage approach. *Environmental Science and Pollution Research*, *24*(32), 25204–25220. https://doi.org/10.1007/s11356-017-0092-1

Tamba, J. G., Nsouandélé, J. L., & Lélé, A. F. (2017). Gasoline consumption and economic growth: Evidence from Cameroon. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(8), 685–691. https://doi.org/10.1080/15567249.2016.1269140

Waheed, M., Alam, T., & Ghauri, S. P. (2006). Structural Breaks and Unit Root: Evidence from Pakistani Macroeconomic Time Series. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.963958

Wang, X., Zou, H., Zheng, Y., & Jiang, Z. (2019). How will different types of industry policies and their mixes affect the innovation performance of wind power enterprises? Based on dual perspectives of regional innovation environment and enterprise ownership. *Journal of Environmental Management*, *251*, 109586. https://doi.org/10.1016/j.jenvman.2019.109586

Yang, L., & Li, Z. (2017). Technology advance and the carbon dioxide emission in China – Empirical research based on the rebound effect. *Energy Policy*, *101*, 150–161. https://doi.org/10.1016/j.enpol.2016.11.020

Zeshan, M., & Ahmed, V. (2013). Energy, environment and growth nexus in South Asia. *Environment, Development and Sustainability*, *15*(6), 1465–1475. https://doi.org/10.1007/s10668-013-9459-8

Zoundi, Z. (2017). CO2 emissions, renewable energy and the Environmental Kuznets Curve, a panel cointegration approach. *Renewable and Sustainable Energy Reviews*, *72*, 1067–1075. https://doi.org/10.1016/j.rser.2016.10.018